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ORIGINAL ARTICLES.

I.—A Western Australian Geologist:

Harry Page Woodward, J.P., F.G.S., Assoc. M. Inst. C.E., F.R.G.S ; Honorary Consulting Geologist and Mining Engineer to the Colony of Western Australia.

(WITH A PORTRAIT, PLATE XVIII.)

EVERYTHING relating to the progress of geology in our Colonies is, or ought to be, of interest to geologists at home; and those who have helped forward this movement are also deserving of recognition and commendation here. The subject of the present notice has left his hammer-marks on the rocks of Western Australia, and has covered many thousand miles on horseback, on foot, by rail and steamboat, from north to south and from east to west of this great region, containing an estimated area of 976,000 square miles, being about nine times that of the United Kingdom, and covering about one-third of the whole Australian Continent.

Harry Page Woodward was born at Norwich, May 16, 1858, and is the son of Dr. Henry Woodward, F.R.S., V.P.G.S., Keeper of the Geological Department in the British Museum (Natural History) ; and grandson of Mr. Samuel Woodward, of Norwich, the well-known geologist and antiquary ; so that he represents the third of a line of geologists, and belongs to a family in which uncles and cousins are also noted men of science. After being educated at University College School, London, he studied geology with Professor Judd in the Royal College of Science, South Kensington, and field-work with his cousin, Mr. Horace B. Woodward, F.R.S., of the Geological Survey of England and Wales. In 1883 he was appointed, upon the recommendation of Sir A. Geikie and Professor J. W. Judd, C.B., Assistant Government Geologist to the Colony of South Australia. Here, under that able geologist Mr. Henry Y. Lyell Brown, F.G.S., the Government Geologist for South Australia, he served for three and a quarter years, covering a large mileage area, and making several reports on the goldfields and other regions of that Colony. He also served for some time as geologist on the Boundary Commission between New South Wales and South Australia, and saw a great extent of the interior of the country. During his residence in South Australia, H. P. Woodward visited Melbourne and inspected the principal mines at Ballaarat and other places in the colony of Victoria. In 1886 he returned to London and

spent a year in the Metallurgical Laboratory of the Royal College of Science On December 2, 1887, having been appointed by the Secretary of State for the Colonies to the post of Government Geologist for Western Australia, he sailed for King George's Sound, arriving in Perth in January, 1888. Here, under the direction of Sir Malcolm Fraser, the Surveyor-General and Commissioner of Crown Lands, and Sir John Forrest, the present Premier, he was called upon to visit, and make reports upon, the vast line of proclaimed goldfields, from Kimberley, Pilbarra, and Ashburton in the north, to the Murchison, Yilgarn, Dundas, and Coolgardie Goldfields in the south. He studied and reported upon the Irwin River and the Collie Coalfields; the Greenbushes Tinfield, near the Blackwood River; and was constantly in request to advise about questions of water-supply in all parts of the colony. In his Annual Report for 1890 he published his first general geological description of the Colony. This was in such demand and so quickly out of print that it became necessary to supply in some way the much needed information. This took the form, in 1894, of a Mining Handbook to the Colony of Western Australia, which has had a phenomenal circulation, and the same year saw the publication of a Sketch-Map of Western Australia (geologically coloured so far as Mr. Woodward's explorations had then extended).

About 1882, Mr. E. T. Hardman (of the Irish Geological Survey), who was employed to report on the Kimberley district, discovered gold there, which proved to be rich and to extend over a large area, but situated as it is, in such a distant part, it did very little good to the settled portion of the Colony.

In 1887, the year of Mr. H. P. Woodward's appointment, Mr. Anstey discovered gold at Yilgarn, about 200 miles east of Perth; and although the earlier finds proved to be of little value, they led to the subsequent discovery of a permanent and payable field a few miles further south. The next discovery, in 1889, east of Roeburn, led to the opening up, in the north-west, of the Ashburton Goldfield, where on the river of that name some rich deposits were also met with, and a large quantity of alluvial gold was sent away in a short time. The Murchison Goldfield followed in 1891, where many rich reefs and a large quantity of alluvial gold were discovered.

The most sensational discovery was that made in 1892, by a man named Bayley, about 100 miles due east of Southern Cross. Here a very large quantity of gold was obtained, and one reef which has been the wonder of the Colonies. In 1893 another (the Dundas Goldfield), still more to the south, was proclaimed, and Mr. H. P. Woodward was sent down there as the first Warden.

The records of the subsequent years are all covered by the Coolgardie Goldfield, which still nearly fills the entire picture of Western Australian mining affairs. From this brief account it will easily be seen that Western Australia has become purely a great gold-mining Colony, and, so long as gold pays, the other interests (save as accessories to this one leading industry) fade into the background.

When in January, 1888, Mr. H. P. Woodward landed in Albany, Western Australia was a Crown Colony; but on October 22, 1890, the new Constitution was proclaimed, and the Colony is now governed by a Parliament composed of two Houses, described as a Legislative Council and a Legislative Assembly, both of which are elected by the people, so that the Government, as well as the prospects of the Colony, have alike undergone a great change in the past ten years.

In 1895 Mr. H. P. Woodward, after serving the Colony through this very arduous period of its career, was induced to resign his position of Government Geologist and enter the service of that old-established firm of Messrs. Bewick, Moreing, and Co., of London and Coolgardie. Mr. Woodward most successfully managed their Coolgardie branch for a year and three months; he then decided in the present year to commence business for himself as a Mining Engineer and Consulting Geologist in Perth and Coolgardie.

It is gratifying to state that although the Ministry did not offer any special inducement to Mr. H. P. Woodward to remain in their employ, they yet recognized his past valuable services by conferring upon him the title of Honorary Consulting Geologist and Mining Engineer to the Colony of Western Australia.

In 1883 Mr. H. P. Woodward was made a Justice of the Peace for the Colony. He was elected a Fellow of the Geological Society in 1884, and is also a Fellow of the Royal Geographical Society. He is an Assoc. Memb. Inst. C.E., a member of the Institute of Mining and Metallurgy; a member of the North of England Institute of Mining and Mechanical Engineers, and President of the local branch of that Society. His name is not unfamiliar as a contributor to the pages of the Geological Magazine.

On December 31, 1890, Mr. H. P. Woodward married Ellen Maude, the second daughter of the Hon. J. F. T. Hassell, of Albany, by whom he has three sons.

Mr. Woodward some years ago, with two others, started a vineyard of some 120 acres at Cooringa, about 50 miles from Perth, which is one of the most admirably cultivated and successful undertakings in the Colony. It is now managed by a Company, and the wines are likely in a few years to be honourably recognized in European as they have already been in Australian competitions.

The Editor of the *British Australasian*, writing of Mr. Harry Page Woodward, under date July 1, 1897, p. 1,180, says:—

"When, the year before last, Mr. Harry Page Woodward resigned the position of Government Geologist of the Colony of Western Australia, I expressed my condolence with the Government on the loss they were sustaining, and congratulated Messrs. Bewick, Moreing, and Co. on the acquisition they were making in securing the services of a gentleman of such high attainments, such extensive local experience, and such sound, trustworthy character. I now learn that Mr. Woodward has severed his connection with the firm of Bewick, Moreing, and Co., and started 'on his own' as a Mining Engineer, having his headquarters at Perth. Biography

has nothing to do with business, but people like to be posted in the antecedents of those with whom they are dealing, and for the information of those on this side of the world who may have occasion to require an honest, skilled report on any mining property in Western Australia I append a few particulars of Mr. Woodward's career, which is naturally not so well known in England as in Australia, where his professional life has been spent. [See ante, p. 385.]

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"Besides his official publications, he has contributed many valuable papers to the learned societies, and has published an extremely useful Mining Handbook to the Colony of Western Australia.

"Mr. Woodward was the first to predict the discovery of artesian water upon the plains to the westward of the Darling Range in Western Australia, where the numerous bores put down are yielding an abundant supply of fresh water. Also, unfortunately, his prediction has up to date proved equally true that no artesian water would be struck upon the goldfields. From their first discovery, Mr. Woodward had the very highest opinion of the value and permanence of the goldfields, advocating strongly the construction of a railway into the interior long before the Government had sufficient confidence in their success to incur the cost of making it. He always in his official capacity as Government Geologist did his best to protect the British investor from the numerous spurious and worthless undertakings put forward by the unscrupulous to ensnare the public, and for which he received the usual thanks.

"He acted for some months as Warden of the Dundas Goldfields, and is thoroughly acquainted with all the goldfields and other mineral areas of the Colony.

"It will be seen from the above that Mr. Woodward has established a right to the title of 'expert,' which seldom appertains to the numerous self-confident gentlemen who without any credentials have assumed the diploma, greatly to their own gain and the loss of the British investor."

II.—The Erosive Power of Rivers and Glaciers.

By R. M. Deeley, F.G.S.

ALTHOUGH we are probably well acquainted with all the chief agents of change, the long-continued action of which has shaped the surface of the earth into mountain and valley, and laid down and metamorphosed the deposits forming those portions of its surface which natural or artificial sections or excavations have enabled us to examine, there still remains considerable difference of opinion, not only as to the particular agent or agents which have formed many deposits, but also as to the rapidity with which changes have been brought about by them in the past. However, since the days when plutonists and pluvialists contended

for the supremacy of fire and water respectively, geologists have come to recognize the fact that the rocky crust of the earth has been caused to reach its present form and condition by the operation of quite a number of agents of change acting both separately and conjointly. But it must not be assumed that any particular agent everywhere and under all conditions produces similar effects, for its work may really be both of a formative and destructive nature. Thus, the sea washes down the cliffs, and then assorts and spreads the débris over the sea-floor. Rivers also, although they erode deep and broad valleys, spread over the lowlands wide deposits of gravel, sand, and brick-earth.

That there is still much to be settled concerning the erosive action of both rivers and glaciers is clear, for papers treating of these subjects frequently appear, the authors of which contend, with some show of reason, that, from a theoretical point of view, the work attributed to these agents is, sometimes, apparently inconsistent with our views concerning their methods of working. More especially is this the case in all matters relating to ice and its work. But ice-work and river-work are so intimately bound up the one with the other, that it is necessary to deal somewhat in outline with the latter if the former is to be made clear.

Rivers, like other elements of change, are not wholly erosive agents, for we have seen that their valley bottoms, even at points distant from the sea, are often covered by widespread deposits of gravel, sand, and brick-earth, having thicknesses closely related to the depths and volumes of water passing down the rivers by which they were formed.

In valleys, the falls of which are rapid, the streams cut vertically into the rocks below, forming gorges or ravines having V-shaped sections. In the lower grounds, where the rivers are less rapid, vertical erosion proceeds slowly, the streams impinging against their banks and more rapidly eroding their valleys horizontally than vertically. The lowland valleys therefore have the typical ⌊⌋ section. Along the bottom the river winds, changing its position constantly, and here and there cutting crescent-shaped masses out of the hillsides. But the stream rebounds from side to side at every turn, and constantly tends to accentuate the sinuousness of its course by cutting into its banks. The river, however, does not become broader, for the material eroded from the outside of a curve, or brought down by tributary streams, is piled upon the inside of the curve, and the channel, as it were, moves bodily sideways. This filling up of the shallows on the inside of every curve with gravel, sand, and brick-earth, results from the fact that the centrifugal force of the water at the surface as it sweeps round a curve is greater than that of the slower current at the river bottom. The flow is consequently diagonally across the bottom, and carries stones, etc., with it, much as the leaves in a saucer of tea are piled up in a central heap when the liquid is stirred. In fact, the mass of water rotates as well as moves forward, sometimes in one direction and sometimes in another,

according as it is deflected by the curves of the river. At such bends the stream is deep and narrow, but in the straight reaches this rotary motion does not occur, and the river shallows and broadens. Gravel and coarse sand are not thrown up, as a rule, on the inside of a curve to a height much exceeding the ordinary water-level of the river. On the top of the coarser material fine sand and mud then collect, mainly at flood times, between the grass reeds and rushes where they root in the shallows, and in this manner the level is raised to flood-line. It thus comes about that the river deposits a bed of alluvium, the lower gravelly portion of which has a thickness equal to that of the river in ordinary flood, whilst the upper surface of the sand and brick-earth on the top indicate the extreme flood rise. But in course of time the sinuosity of the curves becomes so pronounced that the bends approach each other; the river then cuts through the narrow peninsula and deserts a portion of its course, which slowly silts up, and often leads to the preservation in the clay and mud of mammalian and other remains.

The active nature of this looping tendency may be seen by examining any good map of a district where two counties are separated by a river, for in such cases we shall find patches of a county stranded on the opposite side of the stream. As long as the river moves bodily in a lateral direction it, of course, carries the boundary-line with it, but, when a loop is cut off, an island is first formed, and then by the silting up of the old channel through which the boundary passes a piece of land which stood on the right bank is transferred to the left bank, or *vice versâ*. A river by wandering about in this way from side to side may excavate a broad valley and spread out a sheet of alluvium having a width of several miles and a thickness of twenty feet or more. When vertical as well as horizontal erosion is going on some of this gravel is often left on the valley-sides, and forms wide terraces, the highest at any point above the river being the oldest.

It is important to note that the river, although it is spreading sheets of gravel and sand over its valley floor, is also deepening and widening it, i.e., we have erosion and deposition going on hand in hand under the action of one and the same agent. The gravel is everywhere of nearly the same thickness as it is traced away from the stream, is covered by brick-earth except where it has been denuded from the edges of the higher terraces, and rests upon older rocks, which may be of any age, including Pleistocene Boulder-clays, etc.

As a valley becomes deep and approaches the sea-level the fall becomes small and vertical erosion ceases. The river then attacks the sides of its valley only, rapidly carries away the gravel terraces, and we eventually have produced an approximately flat alluvial plain bounded by long steep escarpments. It must be remembered that terraces, which are removed in this final stage, by no means necessarily indicate that the river has paused at any particular level, for gravel must have been left at all heights below the highest

terrace, though only occasional patches may have escaped subsequent denudation. Neither does a flat plain always indicate river-work of this kind, for many of the old river valleys of Norfolk and Suffolk have been depressed at a comparatively recent date beneath the sea, and have slowly been filled up with gravel, sand, and mud brought down by the rivers and brooks, or removed by the waves from the sea cliffs and driven inland. The well-known Broads are merely isolated patches of what were extensive estuaries. Here, however, we are concerned with the effects resulting from the combined action of sea and river.

The changes which occur from season to season in the volume of water passing down stream depend not only upon variations in the rainfall, but likewise upon the porosity of the rocks over which the water flows. Indeed, it often happens that so large a percentage of the rain sinks immediately into the ground, and rises again as springs in the beds of the principal rivers, that the volume of water passing seawards is very considerable even during dry weather. However, although the river channels may be somewhat rapidly and continuously eroded, the general land-surface occupied by insoluble rocks does not suffer very rapidly. But the case is different if the rock should be a soluble one, for the springs are then exceedingly hard and great quantities of material pass to the sea in an invisible form. The ease with which rainwater finds its way into the ground, and after passing for long distances beneath it again comes to the surface, has, we shall find, an important bearing upon one aspect of glacier erosion. Vegetation also has an important effect upon the rate of erosion, for it prevents the loose soil from being readily washed down the slopes, and in estuaries accelerates the rate at which silting up takes place. In this manner climatic effects tell, for in high latitudes the land, which is often bare of vegetation during a considerable portion, if not the whole, of the year, is softened and loosened by frost, and the soil-cap slides bodily down the hill slopes, producing one variety of what we know as "trail" and "underplight." Erosion effected in this way can scarcely be called river erosion: by this we mean the scouring action of the current, largely due to the grinding action of the stones and grit it contains, on the sides and bottom of the channel. Even when the rocks are soft the erosive power of the stream is largely due to the pebbles carried along the bottom.

Now, if from any cause the supply of débris brought down from the hills by lateral streams should be greater than the river can carry away, then instead of erosion taking place and gravel terraces being formed the valley may become choked to a great depth with rough gravel, mud, etc. In cases where the supply of débris brought down in this way is not sufficient to actually choke the main stream, as is the case in the Indus Valley, the lateral streams, where they debouch on the plains, spread out immense fans of gravel on the alluvial deposits. However, in course of time the river cuts into them and hurries the material towards the sea.

The levelling action of rivers is well shown by some of the

valleys in Colorado. There earth-movements of such a character have taken place that mountain ranges have been slowly thrown up right in the track of the rivers. But their erosive power has been sufficiently great to enable them to maintain their courses unaffected, cutting cañons six or more thousand feet deep, and preventing anything like the formation of lake basins in their main valleys. Indeed, the whole tendency of river action is to fill up depressions and bring large areas of country to an almost dead level. But it is notorious that the valleys in many mountainous districts present characteristics which cannot be traced to river action. To explain such phenomena as are there met with we must turn to water working under different conditions, i.e. in the solid form.

Ice as well as running water, there is no doubt, has had a considerable share in the excavation of many valleys. In them we often have smoothed, scratched, and polished rock-surfaces, and heaps and ridges of morainic matter on the slopes or forming low hills stretching across their bottoms. Some of these consist of angular débris carried down on glaciers as medial and lateral moraines, whilst others are crescent-shaped ridges of rough gravel. In the lower grounds especially these give place to wide sheets of Boulder-clay which have often choked up the old valleys throughout the whole or portions of their courses, and in some cases have dammed up the rivers and formed immense lakes.

One interesting feature in particular of glacier-eroded valleys may be mentioned. It is the peculiar step-like way in which they descend from the mountains. First we have the consolidated snow on the mountain-sides descending into wide basins, along which it moves with only a very small fall. It then plunges down a more or less steep slope into a second long basin, and so on. Such a descent is that down which the Rhône Glacier descends into the gravel-covered plain beyond. But a ride down the valley will reveal several such rapid descents separated by nearly horizontal U-shaped stretches. Here and there, however, the cross-section simulates the ⌴ section of a river-eroded valley, but there is reason to believe that the level plain is merely a deep accumulation of the material ejected from the cave at the glacier end. Down the steep slopes separating such level stretches, the road plunges in a series of zigzags, the river passing from the higher level to the lower level through deep V-shaped gorges which it has cut.

Indeed, just as a river tends to make its course through its alluvial plain more and more sinuous by attacking the outside of each curve, so does a glacier exert its main erosive power at or near the bottom of a slope where its direction changes, and where the thrust and pressure upon its bed are at a maximum. In this way is produced a valley which descends to the lowlands in a series of giant steps, the upper ends of which are often occupied by lakes.

The extent to which valleys have been excavated, and their outlines altered by glacier action, is, indeed, very striking, V-shaped valleys having been converted into U-shaped ones, and their

bottoms so deeply cut into that they are frequently occupied by a succession of lakes, many of which rest in true rock basins. Attention has recently been called by Dr. Wallace to a number of the peculiarities of these valleys and lakes. Indeed, upon the question of the origin of lake basins the discussion of the erosive power of ice has largely turned.

The opponents of Ramsay's theory of glacier erosion base their opposition almost wholly upon theoretical considerations of a more or less unsatisfactory kind, holding that ice can only polish and grind, and could not have shaped the valleys and excavated the lake basins in the time we can reasonably expect the glaciers to have been active. Even here, however, their notions of chronology may be woefully at fault. But there are those also who hold that the rate of erosion at and beyond the terminal portion of a glacier is greater than beneath it, and that, consequently, a lake basin can never be formed by erosive action beneath the ice. But this is quite contrary to the teaching of the phenomena to be seen in such positions.

We have pointed out that the handiwork of glaciers in the form of masses of Boulder-clay, gravel, and sand, is so extensive and stretches from the mountains into the lowlands to such great distances, that it is difficult, reasonably, to resist the conclusion that the erosive power of glaciers is very great indeed. Seeing this, some popular writers have attempted to revive the ancient theory of vast floods and great earth convulsions.

Dr. Wallace shows that small lateral valleys seldom, if ever, enter the main valleys at such heights as to cause a lake to branch into them. When such branching occurs it is due to the confluence of two important valleys or to the flow of a glacier over a neighbouring "col." But these features are by no means confined to valleys occupied by lakes. The valley of Chamouni may be well instanced. Here, on one side, the valleys in which the Glacier des Bossons, the Mer de Glace, and the Glacier d'Argentiere rest, terminate abruptly on the valley-side at a great height above the Arne, and the ice from them is precipitated in great cascades down the slope. On the opposite side the upland valleys, although not occupied by glaciers, present the same features, a steep climb bringing one suddenly into an upland basin-shaped valley. The main valley really appears to have been cut like a huge trench through everything.

In everything, however, that relates to ice and its work contradictory phenomena present themselves. In the first place it is a brittle substance, and yet when fragments of it are pressed together, at or near the melting-point, they readily weld together. And, again, O. Mugge[1] has proved that a crystal of ice is not at all viscous, i.e., it will not deform even slowly under the strains produced by small stresses, and is only plastic like moist clay in a direction at right angles to the optic axis; yet glacier ice, which consists of countless

[1] "Ueber die Plasticität der Eiskrystalle": Jahrbuch für Mineralogie, 1895, p. 211.

angular particles of the sizes of peas, beans, or walnuts, all frozen firmly together, presents in mass the properties of a viscous substance like pitch, owing to a molecular action which takes place between the glacier grains,[1] and the glacier moves slowly down its rocky bed in a manner much resembling that of a river. Again, a glacier will often pass over loose deposits of bedded sand and gravel without disturbing them in any way, whilst in other instances it will move rock-masses, measuring hundreds of yards in length for miles, and actually tear up large boulders from its rocky floor. The apparently contradictory effects produced by other agents should warn us not to assume too readily that because ice can polish it cannot excavate, or because it can erode it cannot deposit, or that because in one case it passes over loose sand without disturbing it it cannot break up and remove hard rocks. A consideration of the properties of ice will, however, serve to make such contradictions less startling.

Unlike the water of a river, which is stationary when actually in contact with fixed objects, we have abundant proof that the ice of a glacier when in contact with its floor is not *always* frozen to it; for the glacier carries stones and sand along, and polishes and scratches many of the rocks it passes over. Some writers seem to take it for granted that glaciers are nowhere actually frozen to their beds, and, basing their conclusions upon this assumption, arrive at results which are inconsistent with the facts. But we have no evidence which proves that glaciers really are *always* separated from the rocks upon which they rest by a liquid film. On the contrary, our knowledge of the properties of ice would rather seem to support the opposite view, i.e., that they are frequently firmly frozen to their beds over large areas.

When a piece of lake ice is placed between the opposing faces of a press, and considerable pressure is applied, a portion of it becomes liquid, and the mass assumes a stratified appearance, owing to the formation of liquid layers. To produce these liquid films heat is required, and as this has to come from the ice the whole mass falls slightly in temperature. Indeed, experiment has proved that the freezing-point of water is lowered by pressure. Now beneath a thick glacier, owing to the pressure resulting from its weight, the ice must be at a lower temperature by a degree or so than at its upper surface, and this no matter if the pressure is applied in a vertical direction only. We are here dealing with the same substance in two physical conditions, but the only practical difference that exists between them, for our purpose, is that the ice is enormously more viscous than the water. In the form of water its viscosity is exceedingly small, and for all practical purposes it may be considered as unable to transmit stress if applied in one direction only. As ice, its viscosity being enormously great, it can transmit stresses for yards or even miles in a direct line. We may, consequently, have ice under great pressure

[1] Geol. Mag., Dec. IV, Vol. II, 1895, p. 152.

in contact with water scarcely subjected to any stress whatever. Such conditions, however, are not stable ones, and must give rise to continuous thawing and refreezing.

Between ice in this condition and other rocks, when the water can escape through the porous ground, and is therefore not subjected to any great hydrostatic pressure, it has a freezing-point above that of the ice, and the conditions are favourable for the adherence of the glacier to its bed. The exact nature of the freezing process may be seen by considering the case of a wire loop passed over a piece of ice and weighted at its ends. In such a case the ice under pressure melts, the water moves round the wire and again freezes on its top. In this way the wound is healed as fast as the wire cuts its way down, and the sling finally passes right through the mass without separating it into two portions. When resting upon a porous rock, such as sandstone or gritstone, each particle of quartz pressed into the glacier causes it to melt, and a portion of the low-temperature water, as it escapes, freezes again in the sandstone. Indeed, rough porous surfaces must imbed themselves into the glacier and resist sliding, even should they not actually freeze to the glacier. The tendency of ice is really rather to adhere to the bottom, and drag along with it, and break up, the rocks upon which it rests. In all glaciated districts, as a matter of fact, porous rock-surfaces beneath Boulder-clays, or over which ice has passed, are contorted, torn, and trailed, and but seldom striated or polished.

Soil-cap motion has been largely pressed into service to explain many of the features which have really resulted from the drag of a glacier along its bottom. However, a critical examination of the phenomena presented by some forms of "trail" and "underplight" reveals peculiarities which soil-cap motion, resulting from gravity, could not have caused, the direction of flow indicated by it frequently being uphill, or sufficiently powerful to bend and displace rocky beds. This tearing and breaking-up action of glaciers also comes into play when they pass over hard but jointed and bedded rocks.

There are few geologists who have visited glaciated districts who have not been struck by the great difference in the appearance of valleys viewed from the two aspects, up and down. Looking down, all the surfaces and outlines are seen to be rounded, whereas looking up, rough, rocky, and irregular surfaces everywhere meet the eye. According to the teaching of one school, these rough surfaces were formed before the advent of the glaciers, and represent portions of the old Pre-Glacial weathered surfaces; the subsequent work of ice having merely served to round and smooth one side of them. Such a view affirms that the erosion affected by the glaciers must have been very small. But the angular and unweathered appearance of these craggy surfaces, and the presence of large quantities of angular unweathered rock in the great moraines and sheets of boulder-clay, clearly negative this view, and prove that glacier erosion has really been extremely active.

Now when a glacier moves down a valley it presses heavily against each boss or hummock of rock it touches. Here melting

takes place and the temperature is low, but if the rock be dense and impervious the water cannot readily escape. However, on the top and lee side of the boss the pressure is relieved, the water escapes through grooves, joints, etc., and the ice freezes to the rocks with which it is in contact, tearing up, if the joints allow it to do so, large masses which are then carried forwards. The rate at which erosion is effected in this manner must depend largely upon the direction of the dip and the jointing. In many valleys, however, the rocks are so massive and impervious that they have succeeded in largely resisting the erosive power of the ice. But even in the absence of large hummocks in the path of the glacier the rocky floor must always be so irregular that the local variations of pressure must give rise to local freezing. In this way the whole forward stress of large masses of ice is concentrated *locally*, and the hard floor is dealt with in *detail*. When we remember that a glacier may at one time be moving over a bed of sand and slowly drag along with it an inch or two of its surface without in any way disturbing the lower portions, or glide easily over a dense tough clay, and in another may meet some obstruction, be compelled to move or more or less change its course, and displace the obstruction to a greater or lesser extent, it is clear that we must expect to meet with all sorts of conflicting evidence concerning the real nature of the work glaciers accomplish. Indeed, in the study of glaciated districts we find every kind of action: in one place rocks are polished and scratched, in another deeply grooved, or they may be broken and bent over at a sharp angle at their upper surfaces. Soft clays are bent, crumpled, and contorted, striated and polished stones kneaded eight or more feet deep in marls and clays, and masses of older rock drawn up and buried in the beds above. The Cromer cliffs exhibit splendid examples of this action.

Indeed, just as we find that the deposits formed by rivers vary with the rate of flow, the nature of the rocks they erode, and many other circumstances, and that they are sometimes acting as denuding and at other times as depositing agents, so it is reasonable to argue that the effects wrought by glaciers must also depend upon their rate of flow, their thickness, the nature and surface contour of the rocks over which they move, whether they actually enter the sea or lakes, or terminate on land, etc., etc.

Towards its extremity, where it enters the warm air of the lowlands, the water on the surface of a glacier finds its way through crevasses, or melts its way down the glacier-side to the bottom of the ice-filled valley, and then flows through a wide tunnel until it emerges into the open. The tunnel-sides are of course constantly closing in, and the stream by melting its retaining-walls is continually moving its position. In this way boulders find their way into the stream, are well rounded, and finally ejected along with sand and fine mud.

Outside the tunnel at the end of the glacier the volume of the stream is seldom sufficient to carry away all the coarse débris, which, therefore, collects at the end of the glacier as an enormous

fan, sloping at a small angle, it may be, for miles down the valley, and choking it to depths of hundreds of feet in some instances. Temporary advances of the ice may crush this rough gravel up into great ridges of water-worn rock, such as those, remnants of which are to be seen above Cardiff, Swansea, etc.

During the cold periods which caused the glaciers of Switzerland to stretch out beyond the hills, erode many of the lake basins, and give the valleys their characteristic outlines, the coarse gravel thrown out from the ice caves choked the valleys of the Rhine, Rhône, and other rivers, to great depths. However, during warmer periods, the modern valleys have been excavated through them, and glacial gravel now forms extensive terraces overlooking the newer deposits.

III.—The Geologically Recent Origin of the Surface Contour of Scandinavia and Finland, and its Lessons.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

(*Concluded from the August Number*, p. 361.)

LET us now turn to the angular gravel itself, the so-called Krosstensgrus of the Swedes, which is formed in the main from crystalline rocks, from granite, and gneiss, hälleflinta or petrosilex, crystalline limestones, mica-schists, quartzite diorites, diabases, porphyries, etc. This angular gravel Erdmann not only pronounces to be moraine material, but the only moraine material in the country. How it is possible to correlate this angular drift with any kind of moraine material, or to explain the angular gravel of Sweden by the intervention of ice, I cannot understand, any more than I can understand the application of the same cause to the angular gravels of Southern England and Northern France. That a jointed rock when soaked with water in summer will split into fragments along its joints or cracks when that water is frozen in winter, is true enough, but these variations of temperature are quite impossible under a glacier, and if they were possible they would not cause the splitting of flints, of granite and gneiss and porphyry, into splinters. Nowhere do we find work of this kind being performed in the homeland of glaciers at the present time, nor can I conceive its possibility.

It seems to me as plain as possible that these angular gravels of Sweden, which occur at all levels among the surface beds, have nothing to do in any way with ice. The angular gravel is clearly connected with the angular erratics; they form a continuous series marked by the same features, and they seem to me explainable by one cause only, that which I have already invoked to account for the broken and angular rubble in the Chalky Clay of England, namely, a violent breaking up of the solid matrix of the rocky beds *in sitû* by some subterranean force. Have we any evidence of spasmodic changes of the surface involving the breakage of the strata *in sitû* in the area we are discussing?

One of the most curious facts in recent Glacial literature has been

the substitution of the phrase Baltic ice-sheet for that of Norwegian ice-sheet, which was formerly used. This change of phrase is amply justified. Whatever it was that distributed the Scandinavian boulders or made the inland striæ on the rocks, it was not from the Dovrefeld and highlands of Norway that the force came, but from the much lower land a hundred miles to the east of the watershed. This is admitted by every Scandinavian geologist. Professor J. Geikie himself, in the last edition of his "Great Ice Age," says: "Dr. Törnebohm and Professor Högbom have shown that the glacier-carried erratics of Jemtland demonstrate that the ice passed from east to west—that is, right against the slope of the land; and, according to Keilhau, similar blocks, which could only have come from Sweden, are now found in Trondhjems-fiord; while Pettersen has recorded similar facts in connection with the glacial phenomena of Northern Norway." Mr. Geikie goes on to say: "The most remarkable circumstance in connection with some of these blocks consists in the fact that they occur at a considerably greater height than the rock from which they have been derived. Thus, at Åreskutan, Törnebohm found blocks at a height of 4,500 feet, which could not possibly have come from any place higher than 1,800 feet" (op. cit., p. 424).

This is surely an extraordinary concurrence of facts, so extraordinary that it ought to have received a great deal more serious attention than it has done, for it involves quite a bundle of puzzles and paradoxes, especially when combined with the theory that prevails among the glacialists. How are we to account by any process for the ice-sheet, which they profess to say accumulated, not on the highlands of Norway, but in the lowlands of Sweden, Lapland, and Finland, and thence drove its burden, not only for hundreds of miles horizontally, but for thousands of feet uphill? First, Sweden, Lapland, and Finland are peculiarly dry areas. The only wet winds of Europe are the south and south-west winds: these beat upon the mountains of Norway, which drain them of their moisture, and they pass over into Finland and Sweden as dry winds. How, then, could it ever have been possible, unless the contour of the country has been entirely revolutionized, not only to accumulate an ice-sheet on the land in question, but to make the ice-sheet culminate there? The position involves a meteorological absurdity.

Suppose, however, we could obtain such an ice-sheet: in order that it should drive stones uphill for thousands of feet, or travel for hundreds of miles to the south, it must necessarily have not only been of great depth, but also had a great surface slope, for we can no longer have recourse to a polar ice-sheet to give impetus to the movement. A succession of observers, from Böhtlingk downwards, have destroyed Agassiz's postulate of a polar ice-sheet by showing that the stones were distributed northwards from this area as well as in other directions. If so, how could an ice-sheet, blanketing the comparatively low land of Sweden and Finland, get hold of any boulders at all, or of any stones, for the whole country would have been covered fathoms deep in ice, and, as we know from the case of

Greenland, there are no transported boulders and no moraines where there are no rocks projecting above the surface of the ice. These are some only of the difficulties involved in the position as generally argued. They are paramount difficulties.

The burden of my argument, however, is not so much at this stage to press home the impossibility of this ice-sheet, as to urge that any explanation that is forthcoming seems inadequate to illuminate the position unless we also grant, not merely a slow and secular rise of the land, but that the whole contour and internal relations of the different parts of Scandinavia have been greatly altered since so-called Glacial times by differential movements. I had written this sentence, when I was pleased to find my inference corroborated by the very high authority of Lyell. After describing the dislocations of the chalky beds of Denmark, to which he assigns a very late date, he goes on to say:—"Hence we may be permitted to suspect that in some other regions, where we have no such means at our command for testing the exact date of certain movements, the time of their occurrence may be far more modern than we usually suppose. In this way some apparent anomalies in the position of erratic blocks, seen occasionally at great heights above the parent rocks from which they have been detached, might be explained, as well as the irregular direction of certain glacial furrows like those described by Professor Keilhau and Mr. Hörbye on the mountains of the Dovrefeld in lat. 62 N., where the striation and friction are said to be independent of the present shape and slope of the mountain" ("Ant. of Man," p. 394). Let us prosecute this view somewhat.

That the upward movement of the Scandinavian peninsula, which is conceded by everyone, was not equable and quite continuous, is also generally admitted. It is proved among other things by the terraces existing on the coast of Norway and Lapland, and which mark intermittent periods of repose or of slower movement; but this intermittence will not explain the facts. The facts, in truth, require that we should postulate that at one time there was a much greater and more rapid movement. The barnacles seen by Brongniart and Lyell were found at one height only. If the rise had been more or less intermittent even, we should have had several of these barnacle patches at different heights, or a continuous series of them. It does not seem possible to account for the isolation of the Swedish and other lakes and their separation with their marine animals from the sea, except by a rapid movement. The whole country intervening between the great lakes and the sea is eloquent of violent breakages and ruptures, notably those about Trollhättan. This *a priori* probability is amply supported by all the facts we can collect, and I would venture to press them on the attention of those whose eyes have been closed to all evidence of cataclysmic action by their allegiance to another god.

If the position be just for which we have pressed in a previous paper, that Eastern England and the bed of the North Sea as far east as the Danish islands was bent into a series of enormous north-and-south folds at the very time when the Drift was being distributed, we can hardly doubt that the same movement extended to the

Scandinavian peninsula. This is confirmed by the general contour of the country, which is apparently moulded on the principle of a succession of great hollows and elevations, arranged in roughly parallel lines; one deep hollow being the trough running along the western coast of Norway, another trough being the Gulf of Bothnia and the Baltic, while the intervening peninsula forms a gigantic down; and it may well be that this contour was first given to the country comparatively recently, and in fact contemporaneously with the foldings of the bed of the North Sea and the dislocations of the Chalk in Norfolk and in Denmark, and that when the so-called Drift was deposited not only was the Dovrefeld not the watershed of the peninsula, but the whole country was comparatively flat and plain. If the contortions of the strata were like those further west, and like those forming the Ural Mountains, which we long ago argued belonged to the same era of upheaval, it is also probable that as in those cases they were the results, not of slow movements, but of cataclysmic ones leading to the breakage and disintegration of the crystalline rocks on a great scale. It is only in this way we can account in fact for the prodigious mass of angular or subangular boulders and rock fragments of Scandinavian and Finnish primitive rocks, which not only strew those countries but are also found over Central Russia and Germany. Their number and size seem absolutely inconsistent with their having been the result of ordinary diurnal denudation by frost and rain acting upon exposed peaks, and the country is much too low to admit of this deduction being justifiably imported as a hypothesis from the entirely different conditions in the Alps. It points very forcibly to some tremendous strain which smashed and broke up the beds just as we have seen the Chalk beds of Eastern England and of Denmark were disintegrated and broken. Apart from this, have we any direct evidence of these more or less rapid and gigantic movements and dislocations in Scandinavia? In the high Norwegian mountains the evidence is, of course, not easy to find, since we have no chronometer by which to test when the rupture and dislocation of the crystalline masses of the Dovrefeld took place. We do not know *directly* when the great mass was upheaved, necessarily leading to the creation of the transverse fissures we call fjords, and it would in fact appear from the paucity of Norwegian boulders in the northern Drift, compared with Swedish and Finnish ones, that the Norwegian beds largely escaped the breakage. When we get further east, however, into Sweden we do have such evidence.

In this behalf I would quote some interesting observations of Sefström and Murchison, in Dalecarlia, which have been overlooked and forgotten. The former tells us that M. H. Wegelin had told him that the mountains bounding Norway, Herjedalen and Dalecarlia, did not consist of any fixed continuous strata, but of a mass of large and small pieces of rock which have sharp edges, and therefore have never been rolled, that they were all rent asunder or shattered to pieces on the spot; that none of the blocks are furrowed; and

he elsewhere refers to similar phenomena in the porphyry rocks westward of Lake Siljan ("An Investigation," etc., pp. 112–3). In regard to the same phenomena, Murchison says that in travelling between Upsala and Sala, one is suddenly immersed in a chaos of angular blocks, some of them of gigantic size. Seeing that they were all composed of granitic gneiss, and no proof that these millions of angular blocks were deposited on åsar, and from their linear arrangement, he concluded that they must be simply fragments *in sitû*, the subjacent rock being hidden by their great profusion. He noticed that whenever an elevation presented itself, sometimes not exceeding 15 or 20 feet high, it was covered with angular blocks of all sizes accumulated on a substratum of clay. "On entering Dalecarlia we passed," he says, "a true granitic plateau covered in parts with angular blocks, the mass of which, like those above alluded to, forcibly reminded us, by its superficial aspect, of the broken volcanic *cheires* of Auvergne . . . . they were fragments *in sitû*, the subjacent rock from which they had been broken off appearing here and there. On passing the low hills south of Fahlun the angular blocks and the underlying parent gneiss were clearly exposed. Without such an explanation, the sea of wild and irregular fragments dotted over the plain immediately south of the copper-mines of Fahlun would indeed seem marvellous. . . . . In passing from the Siljan to the Wenjan lake we passed through a country of low wooded porphyry peaks, the parent rock of which is also almost entirely obscured by vast quantities of local angular blocks, and on approaching Johannisholm the observer is suddenly struck with great quantities of sandstone débris, and on traversing the Wenjan lake all other detritus disappears, and the whole mass consists of angular blocks, occasionally of enormous size, composed of hard red, purplish, greenish, or whitish sandstone, which constitutes the cover to a vast expanse of horizontal sandstone, which further to the north is detected beneath this chaos . . . . this *Felsenmeer* or *cheires* consists of enormous angular blocks of purely laminated sandstone and occupies a tract many miles in length, no part of which is more than 100 or 200 feet above the lake. . . . . In numerous spots, indeed, the blocks of sandstone, though completely disjointed and widely separated, conform on the whole to a horizontal arrangement, and it was only at very rare intervals that we could detect the subjacent horizontal rock from which they had been dislocated." Whatever cause, says Murchison, is assigned for the production of this chaos *in sitû*, there can be no sort of doubt that the same agent has operated over several degrees of latitude in Sweden, effecting exactly similar results on innumerable low ridges of hard rock, whether composed of granite, gneiss, of quartz rock, or porphyry, or of finely laminated sandstone. Murchison proceeds to entirely dispute that such a condition of things could possibly result from any kind of subaerial denudation, and appeals to some powerful mechanical agency by which the chaotic arrangement of enormous blocks apparently *in sitû* has been produced, and further

appeals to successive and sudden upheavals of the Northern chain of Scandinavia, aided by a corresponding depression in the south, suggesting that the angular blocks resulted from a number of sudden shocks or jars, which, without throwing the beds up into distinct ridges as in many parts of the world, simply shattered them into numerous fragments by general convulsive earthquakes which affected broad horizontal areas.

Evidence of a similar kind, but not on the same scale, was collected by Sefström from other parts of Sweden. Thus, he says, south of Bröms, on the boundary between the districts of Calmar and Blekinge, the granite is all broken and the pieces lie with their sides irregularly elevated or sunken, much in the same manner as pieces of ice formed at high-water, and the water having sunk the ice rests on an uneven bottom. From this, he says, no other conclusion can be drawn than that the displacement has been caused by some subterranean cause. Further west, near the church of Lösen, are several great fragments of a large slab which has been detached from the main rock below. "It is also," says Sefström, "soon discovered that this slab has been, by a shock from the north, removed a little further south, and that it has been partly crushed to pieces by the shock." Again, Sefström speaks of the fact that in Sweden, on opening new mines the solid rock is seldom found until we reach a depth of from one to two fathoms; until we reach this the mountain is, as it were, shivered, and is full of fractures and fissures filled with a shiny powder of the same or some other rock, and not unfrequently ending in a large open chasm. This is clearly seen about a mile from Fahlun. He also quotes the opinion of Berzelius, that in West Gothland some violent cause has broken and carried away the Silurian rocks, except where protected by a covering of trap. Sefström and Murchison have shown further how the various and sporadic angular blocks which are found in Sweden can be traced right up to these ruinous masses of rock actually *in sitû*, and there can be no doubt that whatever force it was which carried them that force derived them from these centres of distribution. These facts point, it seems to me, to only one reasonable conclusion, namely, that the angular blocks of Scandinavian origin and also the angular gravel, like the angular and subangular débris in the Chalky Clay of England, are the direct result of the breakage of the surface beds at a time when the surface contour of the country was violently altered and remoulded, and they show that the phenomena which we have traced in Norfolk and in the Danish islands are also forthcoming in the Scandinavian peninsula. The phenomena are clearly the result of the immense strain exercised upon beds *in sitû* by sudden upheavals and the operation of more or less violent forces, and they in fact testify to the most important elevation of the land in Sweden having been violent and rapid.

The double conclusion here pressed for, namely, that the larger part of Scandinavia and Finland was recently under the sea, and that the surface of the country has been to a large extent violently and spasmodically smashed and broken, are important conclusions

when taken separately, and when connected together involve still more important ones. The question which immediately suggests itself, considering that these great masses of broken and splintered rock *in situ* are situated in an area where the land must have been submerged by the great North Sea, whose existence everybody allows, is how is it that they are not weathered and rounded and worn, but remain perfectly sharp and untouched? If they had been submerged for any length of time, they must necessarily have shared the fate of the rounded boulders and the rounded gravel of Scandinavia.

On the other hand, if this part of the country has ever been smothered in ice since they were in existence, how comes it that this fact of their being unweathered should be so marked, and that these stones should all be sharply angular and not ice-worn, striated, and smoothed? Ice could not pass for any length of time over these enormous heaps of angular stones and leave them in this condition. The only inference possible seems to be, that if there ever was an ice-sheet here it must have been before the existence of these broken masses, and that neither ice nor water have lain long upon them, or been able to play with them, or to knock them about, or to rub over them. I cannot see how this conclusion is to be avoided.

While, however, it is true that we can in these stones see no traces whatever of ice-action or of the presence of ice, nor yet of their having been submerged for a length of time under a glacial sea, there is evidence that a rapid current of water has passed over them. On this subject I will quote a pregnant sentence of my master, Murchison.

He says:—"Notwithstanding the almost perfect angularity of these broken masses (which are just like the fragments that fall from natural joints in a quarry), it is curious to observe that occasionally (though rarely) a small rounded boulder of porphyry may be detected between their interstices, and that here and there a considerable quantity of sandstone and smaller detritus is mixed with loose sand, and is seen lying around the base and lower edges of the blocks. This fact seems to prove that by whatever cause the blocks were dislocated, water has since passed over and between them, though not with such power in this tract as to abrade them, and merely transporting a very few foreign pebbles, has only had sufficient energy to clear away much of the intermediate loose sand and smaller broken materials, converting them into the fragmentary shingle which we see in the traînées to the south of this sandstone range." (Q.J.G.S., ii, p. 376.)

The whole puzzle now becomes clear on condition that we discard that bastard form of philosophy which persists in attributing results to inadequate causes because of the tyranny of some *a priori* doctrine. The only conclusion which seems available is, that the force which reformed the outline of Scandinavia and converted the sea-bed which once occupied so large a portion of Northern Europe into dry land, acted violently and spasmodically as similar forces on a smaller scale have recently done in Japan.

One result of this was the breaking up of some of the surface crystalline beds of Central Sweden, and probably also of Finland, into a mass of angular débris; but this is only one lesson. The other lesson, which seems as plain as Belshazzar's message, is, that this violent and spasmodic upheaval of the bed of the great North Sea caused it to shed its waters in violent and overwhelming force in all directions, and thus brought about the phenomena which have been such a puzzle and a paradox to the orthodox followers of Hutton and of Lyell, who, like all disciples, have utterly exaggerated the teaching of their masters. This is not my conclusion only. I am only the devoted scholar of much greater men, and among them of the greatest geologist we ever produced in this country, which means the greatest geologist of all time—Murchison—who stands out among most of our contemporary lights like the Eddystone lighthouse would if transplanted among the gas-lamps of Piccadilly. He had the courage to speak out his real convictions, and I can only say Amen.

IV.—Notes on some of the Lakes of Caernarvonshire.

By W. A. Brend, B.A., B.Sc., F.G.S.

SINCE the publication of Mr. Marr's numerous papers on the tarns and lakes of the English Lake District, considerable attention has been paid to the manner of formation of lake-basins in the glaciated regions of Britain; a few notes therefore on some of the lakes of North Wales may not be without interest.

At the head of the Nant Ffrancon Valley, between the range of the Glyders and Carnedd Dafydd, are situated about half a dozen small tarns. The largest of these, Llyn Ogwen, exhibits several features of interest. Rock *in sitú* can be traced all but continuously round the lake. The exit is over rock; on the north side Craig Dhu and Craig-yr-Yrfa slope steeply up to over 3,000 feet; on the south are Tryfan and the Glyders. An alluvial flat extends back from the head of the lake for about half a mile; this is completely rock-bound except for an interval about 40 yards wide just north of Pont Bodesi. The ground here is about 30 feet above the surface of the lake, and is flat and marshy, so that it is impossible to determine whether solid rock or drift material lies beneath the surface. The watershed between the Dena and the Llugwy is about a quarter of a mile further east, and consists of a mass of drift. The extreme shallowness of the lake is remarkable, and rather tends to increase the probability of a drift dam at the point described above. Soundings showed a depth of from 5 to 6 feet at the narrow end, shelving gradually to about 8 feet in the widest part, and then sloping upwards, rather more rapidly, towards the eastern boundary of the lake.

To the south-west of Ogwen, deep set amid frowning precipices, lies Llyn Ldwal, one of the wildest tarns of Wales. Ramsay describes it as being partly dammed up by a terminal moraine, but

he also adds: "the water is, I incline to think, partly retained because it lies in a rock-basin ground out by the old glacier." He admits, however, that he is ignorant of the depths of the tarn. Soundings of Llyn Ldwal do not support this view; the greatest depth obtained was 30 feet, but as the mass of drift at the exit extends down the valley for a considerably greater vertical distance than this, before rock can be traced across, it seems probable that drift damming alone has operated in the formation of the lake.

Llyn Bochlwyd lies to the east of Llyn Ldwal, at a height of 1,800 feet above sea-level. Ramsay considers it to be "slightly dammed up by moraine material." There is no opportunity of sounding this tarn, but if it is a true rock-basin it must be of considerable depth, as the drift at the exit is very thick. Moreover, it is difficult to account for the irregular outline of the tarn on the theory of glacial erosion.

Two other small tarns in the neighbourhood were examined—Llyn-y-Crôm, lying above the gorge of Twll-Du, and Llyn Clŷd to the west of Ldwal. Round neither of these could rock *in sitû* be continuously traced. Ffynnon-y-Lloer, beneath the summit of Carnedd Dafydd, is not described by Ramsay, but drift material is marked round the exit on his map. Rock *in sitû* can, however, be traced within this, but at a point about 40 yards to the north of the end of the lake there is a thick mass of moraine matter, and it is here probably that a dam exists, as the lake is apparently shallow.

To the south and east of the ridge terminating in Moel Siabod lie two tarns—Llyniau-duwaunedd and Llyn-y-foed. The first of these lies in a deep valley, across the end of which runs a ridge of rock, broken, however, in two or three places by marshy and peat-covered intervals, beneath which drift material might lie. Llyn-y-foed at first sight looks very much like a rock-basin, rock *in sitû* being exposed nearly the whole way round; at the south-west angle of the lake, however, a deep depression, about 30 yards wide, appears to be filled with drift material.

Several features of interest are presented by the group of long, narrow, and roughly parallel lakes, which lie to the north of the Capel Curig and Bettws-y-Coed road, and drain into the valley of the Conway. Llyn Geirionydd, the most easterly, is situated at a height of 616 feet above sea-level. The western side of the lake is formed by the rugged mass of Mynydd Deulyn rising abruptly from the margin to over 1,300 feet. Rock *in sitû* can be traced continuously from the left bank of the outflowing stream to just behind the cottage Tal-y-llyn at the head of the lake. Here there is an alluvial flat about 200 yards wide, and then rock is again exposed in the stream flowing from the reservoir. By going a considerable distance in a south-westerly direction solid rock can be traced round the tract of alluvium. The eastern shore of the lake is formed by the steep grass-covered slopes of Pen-y-Drum, varying from 900 to 1,000 feet in height. To the east

of the exit stream rock *in sitû* can be detected along the footpath, but between this and the stream is an area of which, though it does not look like a drift-filled depression, it is not possible to speak with certainty. It is flat and marshy, and though drift is not visible neither is rock. The narrowest point is about 10 feet below the level of the lake; a drift dam here, then, must be 40 feet thick, as the maximum depth of the lake is 50 feet. It may be pointed out that the shape of the western margin of Llyn Geirionydd renders any explanation of its formation by glacial erosion difficult to accept.

About three-quarters of a mile to the west on the other side of Mynydd Deulyn is Llyn Crafnant, situated 602 feet above sea-level. The stream, which drains the lake, flows out through a gorge about 100 yards long: on the left bank a cliff rises nearly vertically for about 40 feet, and then slopes back; on the right bank is a path about 3 yards wide, and then a steep rocky declivity. Rock *in sitû* occurs below the path at intervals along the margin of the stream. The actual bed of the stream is filled with large boulders, and it is impossible to trace rock across it. The narrowest place is a point about 10 feet below the level of the surface of the lake; here the rock-walls of the stream are 17 yards apart; in other places the distance between them varies from 20 to 30 yards. If the loose material seen in the bed of the stream really dams up the lake, it must descend to a very considerable depth, as the writer obtained several soundings over 70 feet, and Mr. Kingsley, who sounded the lake some years ago for the Ordnance Survey, found 90 feet in one place. As the fall through the gorge is considerable, and the stream pretty strong, it does not seem probable that the loose material can be of any great thickness.

Considerable attention has been paid to the description of the exit of Llyn Crafnant, as there seems to be no other place where the lake is likely to have been dammed. Bare and rugged mountains rise up continuously all round the lake, in one place only below 1,000 feet high. This is a narrow depression through which the path from Llyn Geirionydd runs; the highest point is about 360 feet above the surface of the lake. Here the interval across which rock cannot be traced is about 25 yards wide; 200 yards south-east of this the width is reduced to less than 20 yards. If this depression represents a drift-filled valley damming the lake, it is at its highest part from 60 to 80 feet wide for about 200 yards and at least 430 feet deep. The existence of such a rift as this seems highly improbable.

The lake is shallow at the narrow end, and shelves down gradually to about 30 feet just beyond the first tributary stream; from this point it shallows to about 15 feet opposite the next tributary. From here it deepens rapidly to about 70 feet near the centre of the lake. A depth of between 50 and 70 feet is maintained for some distance, and then it rapidly shallows up to the alluvial flat.

A large lake, Llyn Cawlyd, about a mile to the north-west of

Crafnant, deserves a few words. It is girt in by mountains on either side, and to the south-west; the stream which drains the lake flows in a north-easterly direction, through a gently sloping valley filled with drift and alluvium. The narrowest part of the valley is some distance above Pont Brwynog, about 100 feet below the level of the lake. Here there are masses of rock *in sitû* about 130 yards apart. The shape of the lake-basin is interesting; the deepest part is near the head of the lake, where it reaches 230 feet; for some distance the depth varies from 180 to 210 feet, and then the lake shallows gradually up to the exit. If the lake is formed by the blocking of this valley, the drift must be 130 feet thick at the narrow area mentioned above, which necessitates a rate of fall of two in three of the sides of the valley buried beneath the drift. This is very much greater than the rate of fall on either side above the drift.

It is possible that in the case of Llyn Crafnant and Llyn Geirionydd, one almost certainly a rock-basin, the other very possibly so, earth-movements may have been wholly or partially responsible for their formation. The same agency may conceivably have operated in the case of Llyn Cawlyd.

Llyn Eigiau lies to the east of Carnedd Llewelyn. It is quite shallow, judging by the rushes which grow a long way into it. The eastern shore is low and covered with peat, which probably conceals moraine material.

The writer is indebted to Mr. J. E. Marr, F.R.S., for many kind suggestions and criticisms; and to Mr. Kingsley for information as to the depths of Llyns Geirionydd and Cawlyd.

V. — On a Jurassic Lamellibranch and some other associated Fossils from the Sarawak River Limestones of Borneo; with a Sketch of the Mesozoic Fauna of that Island.

By R. Bullen Newton, F.G.S.

The Mesozoic Fauna of Borneo.

CERTAIN deposits in the neighbourhood of the Seberuang River, a tributary of the Kapuas in Western Borneo, were described by R. Everwijn[1] in 1854 as containing numerous so-called "Nummulites." Similar organisms were obtained at a later date from the same district by Dr. F. Schneider, which were examined by Dr. K. Von Fritsch[2] and proved to belong to the genus *Patellina*. Two new forms were described and figured under the names of *P. scutum* and *P. trochus*, whilst the occurrence of *Patellina* itself suggested to Von Fritsch the probability of the beds in question being of Cretaceous age. A further study of this material induced

[1] "Voorloopig onderzoek naar Kolem in de landschappen Salimbouw Djonkong en Boenoet in de Residentie Westerafdeeling van Borneo": Nat. Tijdsch. Nederlandsch. Indië, 1854, vol. vii, p. 387.

[2] "Patellinem von der Westseite von Borneo": Palæontographica, 1878, suppl. 3, pp. 144, 145, pl. xix.

Professor K. Martin[1] to abolish Von Fritsch's supposed new species in favour of the more typical form of the genus *Patellina* (*Orbulites*) *concava*, Lamarck, a fact of considerable importance, since it enabled him to fix upon the Cenomanian stage of the Cretaceous series as the definite horizon for these particular beds of Western Borneo. In 1883 some molluscan and other remains were obtained from near Sajor on the river Seberuang through Mr. R. D. M. Verbeek,[2] and examined by Dr. H. B. Geinitz[3] and Dr. G. Böttger, who both regarded them as of Lower Senonian age. They were determined as follows[4]:—

Natica cf. *Gentii*, Sby. (*canaliculata*, Mant.).
N. lamellosa, Röm.
Phasianella, sp.
Avellana, sp.
Panopea cf. *gurgitis*, Brong.
P. cf. *mandibula*, Sby.
Pholadomya (*Goniomya*) *designata*, Goldf.
Astarte, sp.
Trigonia cf. *limbata*, D'Orb.
Lyonsia cf. *Germari*, Gein.
Vola cf. *quadricostata*, Sby.
Modiola cf. *capitata*, Zittel.
Gervillia cf. *solenoides*, Defr.
Spondylus, sp.
Lima, sp.
Arca, sp.
Ostrea, sp.
Hemiaster Regulusanus, D'Orb.
H. sublacunosus, Gein.
H. plebejus, Novák.
Patellina, sp.

An interesting Cretaceous fauna was next discovered at numerous localities in the Martapura district of the south-eastern part of the island, which has been fully monographed by Professor K. Martin.[5] The remains of some Rudistiform shells were first described under *Sphærulites* and *Radiolites*, but without specific names on account of their imperfect preservation, though supposed to show some relationship to Stoliczka's species from Southern India, *Radiolites mutabilis* and *Sphærulites Indica*. A second memoir dealt with the remaining groups of these fossils, embracing the Echinoids, Brachiopods, Lamellibranchs, Gasteropods, and Cephalopods. The entire fauna was regarded as of Upper Cretaceous age, and on account of its resemblance to Southern Indian forms Martin recognized it as equivalent to the Arrialoor group of that country. The complete list of these specimens is as follows:—

Cidaridarum, sp. indet.
Terebratula Dutempleana, D'Orb.
T. (*Terebratella?*) *Borneensis*, sp. nov.
Ostrea (*Exogyra*) *ostracina*, Lam.
O. (*Alectryonia*) *Martapurensis*, sp. nov.
Ostrea (*E.*) *Borneensis*, sp. nov.
Ostrea, sp. indet. (4–5 species).
Pecten, sp. indet.
Vola quinquecostata, Sby.
Modiola Hoozei, sp. nov.

[1] "Untersuchungen ueber den Bau von *Orbitolina* (*Patellina*, auct.) von Borneo": Sammlungen geol. R.-Mus. Leiden, 1890, No. 20, vol. iv, part 7, pp. 209–231, pls. xxiv, xxv.

[2] "Over het voorkomen van Gesteenten der Krijtformatie in de Residentie Westerafdeeling van Borneo": Versl. Med. K. Ak. Wetenschappen, 1883, vol. xix, p. 39.

[3] "Ueber Kreidepetrefacten von West-Borneo": Zeitsch. deutsch. geol. Ges. 1883, vol. xxxv, p. 204.

[4] The nomenclature given in these lists of fossils is that of the authors themselves, no revision of the same having been attempted by the present writer.

[5] "Ueber das vorkommen einer Rudisten fuehrenden Kreideformation im Suedoestlichen Borneo"; "Die Fauna der Kreideformation von Martapoera": Sammlungen geol. R.-Mus. Leiden, 1889, Nos. 18, 19, vol. iv, parts 4, 5, pp. 117–197, pls. xiii–xxi.

Trigonia limbata, D'Orb.
Cardita (*Venericardia*) *Hoozei*, sp. nov.
Astarte (?) *Martapurensis*, sp. nov.
Crassatella proteus, sp. nov.
C. (?) *Borneensis*, sp. nov.
C. macrodonta (?), Sby.
Ptychomya Indica, sp. nov.
Sphærulites, sp. indet.
Radiolites, sp. indet.
Cardium Djaricanense, sp. nov.
Cyprina (*Venilicardia*) *mordax*, sp. nov.
Roudairia gigantea, sp. nov.
Venus, sp. indet.
Cytherea Assahanensis, sp. nov.
Pholadomya Sundaica, sp. nov.
Natica (*Gyrodes*), sp. indet.
Nerinea Sedetensis, sp. nov.
N. Hoozei, sp. nov.
N. Sundaica, sp. nov.
N. Borneensis, sp. nov.
N. Martapurensis, sp. nov.
N. Horneri, sp. nov.
N. Djaricanensis, sp. nov.
N. (*Itieria*) *Schwaneri*, sp. nov.
Alaria, sp. (?).
Strombus (*Pugnellus*), sp. indet.
S. Martapurensis, sp. nov.
Helix, sp. indet.
Nautilus Trichinopolitensis, Blanf.
Ammonites (*Acanthoceras*), sp. indet.
Scaphites, sp. indet.

During the following year Dr. Martin[1] described some Lamellibranch shells from Sepang and Soengei Mottong, Western Borneo, as *Gervillia Borneensis*, sp. nov.; *Gervillia*, sp. indet.; *Corbula*, sp. indet. They were obtained from the "Alte Schieferformation" (a name given to a series of deposits embracing argillaceous and siliceous schists, sandstones, conglomerates, and in other ways assuming the character of a Palæozoic formation), and judged to be of Mesozoic age, possibly Cretaceous. In 1895 the same author[2] announced the discovery of Jurassic Mollusca by Mr. Wing Easton and Dr. J. Bosscha at various localities in or near the Sambas district of Western Borneo, which in the succeeding year formed the subjects of separate papers by Dr. F. Vogel[3] and Dr. P. G. Krause.[4] Dr. Vogel's list includes the following species, all of which are new, and the author is inclined to refer them to the Weisser Jura horizon of the Oolites:—

Protocardia crassicostata.
P. tenuicostata.
P. multiformis.
Corbula Borneensis.
Exelissa septemcostata.
Amauropsis (?) *Borneensis.*
A. (?) *Sambasana.*
Strombus, sp. (?).
Ficula, sp. (?).

Dr. Krause's contribution is concerned with the description of some Liassic Ammonites and a doubtful form of *Inoceramus*, from an argillaceous shale. The Cephalopods are referred to the genus *Harpoceras*, of the group *H. radians*, Reinecke, the typical species of which is characteristic of an Upper Lias age.

[1] "Versteinerungen der Sogenannten alten Schieferformation von West-Borneo": Sammlungen geol. R.-Mus. Leiden, 1890, No. 20, vol. iv, part 7, pp. 198–207, pls. xxii, xxiii.

[2] "Die Mesozoischen Schichten von West-Borneo": Sammlungen geol. R.-Mus. Leiden, 1895, No. 21*a*, vol. v, part 2, pp. 29–34.

[3] "Mollusken aus dem Jura von Borneo": Jaarb. Mijnw. Ned. O.-Indië, 1896, vol. xxv, pp. 1–27, pls. ix, x: Sammlungen geol. R.-Mus. Leiden, 1896, Nos. 21*b*, 22, pp. 127–153, pls. ix, x.

[4] "Ueber Lias von Borneo": Jaarb. Mijnw. Ned. O.-Indië, 1896, vol. xxv, pp. 28–42, pl. xi: Sammlungen geol. R.-Mus. Leiden, 1896, Nos. 21*b*, 22, pp. 154–168, pl. xi.

TABULAR LIST OF THE MESOZOIC FAUNA OF BORNEO, INCLUDING THOSE FORMS REFERRED TO IN THE PRESENT PAPER.

Genera and Species.	Lias.	Oolite.	Cretaceous.
Cephalopoda.			
Ammonites (Acanthoceras), sp. indet. ...	—	—	x
Harpoceras (group H. radians, Reinecke) ...	x	—	—
Nautilus Trichinopolitensis, Blanf.	—	—	x
Scaphites, sp. indet.	—	—	x
Gasteropoda.			
Alaria, sp. (?)	—	—	x
Avellana, sp.	—	—	x
Amauropsis (?) Borneensis, Vogel	—	x	—
A. (?) Sambasana, Vogel	—	x	—
Exelissa septemcostata, Vogel	—	x	—
Ficula, sp. (?)	—	x	—
Helix, sp. indet.	—	—	x
Natica cf. Gentii, Sby. (canaliculata, Mant.)...	—	—	x
N. lamellosa, Röm.	—	—	x
N. (Gyrodes), sp. indet.	—	—	x
Nerinea Borneensis, Martin	—	—	x
N. Djaricanensis, Martin	—	—	x
N. Hoozei, Martin	—	—	x
N. Horneri, Martin	—	—	x
N. Martapurensis, Martin	—	—	x
N. (Itieria) Schwaneri, Martin	—	—	x
N. Sedetensis, Martin	—	—	x
N. Sundaica, Martin	—	—	x
Phasianella	—	—	x
Strombus (Pugnellus), sp. indet.	—	—	x
S. Martapurensis, Martin	—	—	x
S., sp. (?)	—	x	—
Lamellibranchiata.			
Alectryonia amor, D'Orb.	—	x	—
Arca, sp.	—	—	x
Astarte, sp.	—	—	x
A. (?) Martapurensis, Martin	—	—	x
Cardita (Venericardia) Hoozei, Martin ...	—	—	x
Cardium Djaricanense, Martin	—	—	x
Corbula, sp. indet.	—	—	x
C. Borneensis, Vogel	—	x	—
Crassatella (?) Borneensis, Martin	—	—	x
C. proteus, Martin	—	—	x
C. macrodonta (?), Sby.	—	—	x
Cyprina (Venilicardia) mordax, Martin ...	—	—	x
Cytherea Assahanensis, Martin	—	—	x
Gervillia cf. solenoides, Defr.	—	—	x
G. Borneensis, Martin	—	—	x
G., sp. indet.	—	—	x
Inoceramus, sp.	x	—	x
Lima, sp.	—	—	x
Lyonsia cf. Germari, Gein.	—	—	x
Modiola cf. capitata, Zittel	—	—	x
M. Hoozei, Martin	—	—	x

Genera and Species.	Lias.	Oolite.	Cretaceous.
Ostrea, sp.	—	—	x
O. (Exogyra) ostracina, Lam.	—	—	x
O. (E.) Borneensis, Martin	—	—	x
O. (Alectryonia) Martapurensis, Martin ...	—	—	x
O., sp. indet. (4–5 species)	—	—	x
Panopea cf. gurgitis, Brong.	—	—	x
P. cf. mandibula, Sby.	—	—	x
Pecten, sp. indet.	—	—	x
Pholadomya (Goniomya) designata, Goldf. ...	—	—	x
P. Sundaica, Martin	—	—	x
Protocardia crassicostata, Vogel	—	x	—
P. tenuicostata, Vogel	—	x	—
P. multiformis, Vogel	—	x	—
Ptychomya Indica, Martin	—	—	x
Radiolites, sp. indet.	—	—	x
Roudairia gigantea, Martin	—	—	x
Sphærulites, sp. indet.	—	—	x
Spondylus, sp.	—	—	x
Trigonia cf. limbata, D'Orb.	—	—	x
T. limbata, D'Orb.	—	—	x
Venus, sp. indet.	—	—	x
Vola quinquecostata, Sby.	—	—	x
V. cf. quadricostata, Sby.	—	—	x
Brachiopoda.			
Terebratula Dutempleana, D'Orb.	—	—	x
T. (Terebratella ?) Borneensis, Martin ...	—	—	x
Bryozoa.			
Heteropora (related to H. conifera, Lamx.) ...	—	x	—
Actinozoa.			
Stylina, sp.	—	x	—
Spongiæ.			
Corynella (?), sp.	—	x	—
Foraminifera.			
Patellina (Orbulites) concava, Lamarck (=P. trochus and P. scutum, Fritsch) ...	—	—	x

Remarks on the Shell and its Locality.

The recognition of a European Jurassic Lamellibranch in the rocks of Borneo is thought to be worthy of recording as an addition to our slight knowledge of the Mesozoic fauna of that country. The shell in question, identified as *Alectryonia amor*, D'Orbigny, consists of four fragments, one being a nearly perfect upper valve measuring 72 millimetres from end to end. Each of these specimens is of blackish colour, though covered in places with a loose fawn-tinted

sandy material, and stands out in relief on a greyish blue-black compact limestone intersected with veins of calcite, and bearing a water-worn surface. An accompanying manuscript label gives the following information:—"Borneo. *Ostrea colubrina*? Goldf., pl. lxxiv, fig. 5. M.P.G."; the latter letters pencilled on the corner implying that the specimens were transferred from the Museum of Practical Geology to the British Museum during the year 1880.

Considering the extent of Borneo, said to thrice exceed the superficial area of Great Britain, it is to be regretted that no more precise locality has been preserved with the specimens, although a comparison with some further limestones from the same island has enabled me to partially supply this information. I refer to material in the Geological Society's Museum (presented by Mr. Jas. Russell in 1861) localized as from "Bousoe" (probably Busau), and to other specimens in the British Museum, presented by Mr. A. H. Everett a few years since, from Bidi, Busau, Jambusau, Sadong, etc., all of which localities are situated in the north-western part known as the Residency of Sarawak,[1] on or near the river of the same name. These limestones possess similar petrographical characters and the same water-worn appearance, though several of them present whitish, decomposed, weathered surfaces, besides having their fossiliferous structures (corals, etc.) more or less elevated above the general level of the matrix; so marked is this resemblance that I have no doubt the molluscan remains were obtained from the Sarawak River District, and most probably from either Bidi or Busau.

I may here insert the following observations on the geology of this part of Borneo, published by Mr. A. H. Everett[2] in 1878:—"This district consists of an ancient blue limestone (Palæozoic?), on which is superimposed unconformably a thick series of sandstones, conglomerates, and clay-shales, constituting the most extensive series of beds in this part of Borneo; and on these last lie strata of clay-shales, alluvial clay, river gravels, etc., of very recent origin. Piercing the limestone and sandstone we find granite and a variety of igneous and trappean rocks—basalt, porphyrite, greenstones, etc., these latter being developed in great abundance in the antimony districts where they are in immediate contact with the limestone. The latter formation, in which the lodes of antimony are seen *in situ*, is locally rich in fossil organic remains, but I am unable to say whether they have been examined by a competent geologist with a view to approximate the age of the rock; the planes of stratification can seldom be made out with any approach to certainty, but where they are evident they show that the originally horizontal beds have been uptilted almost on end and much denuded; and there is abundant proof that a very considerable interval in time elapsed between the close of the limestone formation and the commencement of the succeeding sandstone series."

[1] See map of this region by W. M. Crocker in the Proc. Roy. Geogr. Soc. 1881, N.S., vol. iii, p. 256.

[2] "Notes on the Distribution of the Useful Minerals in Sarawak": Journal Straits Branch Royal Asiatic Society, 1878, p. 14.

DESCRIPTION OF SHELL.

Alectryonia amor, D'Orbigny. Knorr (Walch) : Naturges. Verstein. Merkw. 1768, part 2, pl. D ii, figs. 5–7.

Ostracites crista-hastellatus, Schlotheim : Petrefactenkunde, 1820, p. 243 (name trinomial, and therefore not acceptable).

Ostrea colubrina, Goldfuss : Petrefacta Germaniæ, 1833, vol. ii, p. 8, pl. lxxiv, figs. 5*a–e* ; *non* Lamarck, 1819.

Ostrea amor, D'Orbigny : Prodrome Paléontologie Stratigraphique, 1849, vol. i, p. 342.

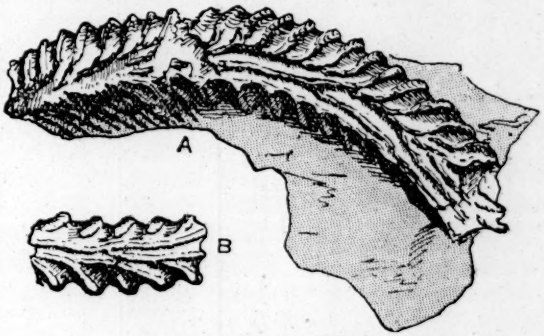
Ostrea hastellata.

Ostrea rastellata, Quenstedt : Der Jura, 1858, p. 750, pl. xci, fig. 27.

Ostrea hastellata, P. de Loriol : Mém. Soc. Pal. Suisse, 1881, vol. viii, p. 97, pl. xiii, figs. 8, 9.

Ostrea (*Alectryonia*) *hastellata*, P. de Loriol : Mém. Soc. Pal. Suisse, 1892, vol. xix, p. 346, pl. xxxvi, fig. 8 ; ibid. 1894, vol. xxi, p. 72, pl. ix, figs. 1–3.

The first systematic diagnosis of this species was furnished by Goldfuss under the name of *O. colubrina* as follows :—"*Ostrea testa æquivalvi lineari-lanceolata, arcuata, dorso plano lateribus abruptis, plicis dorsi obliteratis lateram subacutis numerosis.*"



Alectryonia amor, D'Orb.

Middle Oolite : Sarawak River District, Borneo.

A. Nearly perfect upper valve (nat. size).

B. Part of lower valve of another specimen showing longitudinal dorsal ribs and grooves (nat. size).

(Originals in the British Museum.)

The shell is elongate, equivalve, narrow, and arcuate ; dorsal area flat, with longitudinal ribs and grooves ; lateral surfaces almost vertical, and bearing numerous elevated dentiform plications which become somewhat hook-shaped on the dorsal margins ; inner side possesses a small aliform expansion, which is covered with more closely-set plications than those on the ordinary sides of the valves.

Affinities.—Among the distinguishing characters of this shell may be mentioned (1) its generally narrow form, (2) its steep vertical sides, and (3) its flattened dorsal area, which is ridged and grooved with elevated longitudinal ribs, the main one bifurcating after a certain distance, then finally merging into smaller ramifications.

There appear to be two Cretaceous species with which this form may be confounded, viz., *A. pectinata*, Schlotheim, sp., and *A. carinata*, Lamarck, sp. The former, however, has more oblique lateral surfaces and is more strongly arched; the dorsal area is not flattened, but bears numerous V-shaped ribs, which extend from the side plications, forming irregular grooves or canals. *A. carinata* possesses deeper and more compressed valves, and a much narrower dorsal region, which although rather similarly ribbed at intervals, yet differs from the present species in having prominent, elevated, and curved points forming the dorso-marginal terminations of the numerous lateral plications.

A form of this genus (*A. Martapurensis*) has already been described from the Cretaceous rocks of Southern Borneo, which differs from the present shell in possessing a keel-like back formed by the meeting of the lateral plications in that area. Excellent figures of *A. amor* have been published, but those given by Goldfuss, Quenstedt, and P. de Loriol are probably the most striking for details. These represent specimens from the Corallian of Nattheim and Switzerland, which are usually better preserved than those from other localities.

Distribution.—According to D'Orbigny the species is restricted to the Middle Oolite, having been found in the Callovian of Pizieux, Villers, and St. Scolasse-sur-Sarthe, in France; Streitberg and Amberg in Germany. It is also recorded from the Corallian of Nattheim in Germany, Switzerland (Bernese Jura), and from similar rocks at Châtel-Censoir, Loix, and Île de Ré in France. Other localities represented by specimens in the British Museum are Viel St. Reine (Corallian) and Vaches Noirs (Oxfordian). We have no record of specimens from the English Oolites.

Observations on the other Limestone Structures.

A microscopical examination of Mr. Everett's limestones in the British Museum has led to the following results:—(1) The identification, with Dr. J. W. Gregory's assistance, of the Bryozoan genus *Heteropora*, exhibiting a colony formed of innumerably small zoœcia with faint traces of mesopores, and longitudinally displaying some horizontal tabulæ or diaphragms; in these and other details suggesting a relationship to *H. conifera* of Jurassic seas. (2) In the same block of matrix and close to the specimen of *Heteropora* can be seen the well-defined calices of a coral possessing septa of the hexameral type, and which Dr. Gregory recognizes as *Stylina*, a genus ranging from Trias to Cretaceous times, with a numerous representation in Oolitic rocks, especially those of Corallian age. (3) A sponge has been determined for me by Dr. G. J. Hinde as belonging to the group of the Calcispongiæ and probably to the genus *Corynella*. The specimen appears to me to resemble some Corallian forms of this genus found in the Nattheim beds of Germany.

Quite a number of organisms enter into the constitution of these limestones, but they are more or less obscure and difficult to determine; those referred to on the present occasion are thought to be sufficient for assisting in determining their geological horizon.

CONCLUSION.

So far as I have been able to ascertain, no definite palæontological date has yet been adduced in settlement of the geological age of the Sarawak River limestones, which appear to have been regarded by some authors as Palæozoic. The water-worn varieties especially resemble an ancient formation such as the Devonian coral limestones of Northern Queensland; and the peculiarities of *Heteropora*, which remind one so strongly of the various Monticuliporoid structures found in the older rocks, seem to add considerably to this suggestion. But neither the sponge, nor the coral, nor the mollusc can be mistaken for Palæozoic organisms, and we have in such forms of life evidence of the first character to prove their Mesozoic origin. The example of *Alectryonia amor* allows us to go still further, for this is a good Middle Oolite species, and without the assistance even of the other structures is sufficient to prove that the deposition of the limestones in question must have taken place during that particular period of Jurassic history.

REVIEWS.

I.—SOME GEOLOGICAL EVIDENCE REGARDING THE AGE OF THE EARTH. By J. G. GOODCHILD, H.M. Geol. Survey, F.G.S., etc. 8vo. (Edinburgh: McFarlane & Erskine, 1897.) (Reprinted from Proc. Roy. Phys. Soc. Edinburgh, vol. xiii, pp. 260–303.)

THE age of the Earth has to be calculated from the physical and biological changes of which the rocks bear evidence. The author thinks that their value-in-time has to be taken with reference to changes of the same nature now in progress—that is, with normal uniformity of action in general, but allowing for catastrophism in certain cases. Even in rocks formed previously to those that yield definite organic remains, there is clear evidence, says the author, of winds, tides, and currents having acted as they do now. "Even as far back as the commencement of the Cambrian Period the two great geological factors, *solar energy* and *gravitation*, appear to have operated then very much as now. To a geologist this merely indicates that the close of what has been termed the 'Astronomical History' of the Earth terminated many millions of years prior to the Cambrian Period; and that the Earth must have been in a condition suitable for life through a long period of time when the Archæan rocks were in process of formation."

In calculating the time required for the Physical Changes that have taken place during the Tertiary Period, Mr. Goodchild refers chiefly to the Hebrides for the basis of some of his calculations with regard to changes in the early part of the Tertiary Period. He regards the climax of the Glacial Period to have been about 20,000 years ago; the excavation of the Hebridean and Scotch valleys required 16,000,000 years, if only at the rate of one foot in 2,000 years; and the growth of the Great Old Skye volcano, presumably once 8,000 feet high, and formed at the rate of about one foot in 300 years, took up some 2,400,000 years in the Oligocene Period. In the previous Eocene Period the extensive Nummulitic Limestone

had been formed. For all his calculations the author details the statements, statistics, and opinions advanced by many observers. The mode of formation and rate of growth of marine limestones are carefully estimated, and one foot in 25,000 years is taken as a fair rate to allow for the formation of marine limestones other than coral-reefs. The Nummulitic Limestone, if only 3,000 feet thick, required no less than 75,000,000 years for its formation. Thus, a total of 93,420,000 years must have elapsed between the commencement and the close of the Tertiary Period.

In like manner the author calculates the time required for the formation of the Chalk and other Cretaceous strata, explains his views of the relative time-value of the tilting and denuding necessarily associated with unconformities, and proceeds to the consideration of the other Mesozoic formations, and those of the Upper and Lower Palæozoic times. His remarks on the Carboniferous Series are noteworthy. Very different are the estimates that have been made for the time necessary for the production of a foot of coal—thus, by Huxley 500, Boussingault 3,600, Phillips 1,530, Croll 1,600, Humboldt 1,800 years.

These suppositions are for the terrestrial origin of coal; but Mr. Goodchild thinks that some coal-seams may have been sufficiently marine to allow of an average estimate of one foot in 3,000 years. At all events, for the 105 feet of coal-seams near Manchester he would give 315,000 years. This, with 10,500,000 years for the 7,000 feet of Carboniferous sandstones (at one foot in 1,500 years), and 21,000,000 years for 7,000 feet of Carboniferous shales (at one foot in 3,000 years), makes up the sum for the Upper Carboniferous Group.

The author's summary of the time required for the known geological series is as follows:—

	Time in Years.
For the Tertiary Period	93,420,000
For the formation of the Chalk, Upper Greensand, Gault, and Lower Greensand	31,400,000
Pre-Cretaceous Unconformity in Britain	13,200,000
Time required for the deposition of the Jurassic-Wealden Series	59,400,000
Time represented by the Tyrolian and Panormian (together comprising our *Trias* and *Permian*) rocks	87,500,000
Unconformity at the base of the Lower New Red in Britain	45,000,000
Duration of the Upper Carboniferous Period in Britain ...	31,815,000
Time required for the formation of 2,500 feet of Carboniferous Limestone	62,500,000
Time represented by the Continental Devonian Limestones...	125,000,000
Duration of the period represented by the Salopian (Silurian) rocks	56,000,000
Chronological value of the Unconformity at the base of the above	12,000,000
Time required for the accumulation of the Upper Ordovician rocks	12,000,000
For the Lower Ordovician rocks	33,000,000
For the Upper and Middle Cambrian rocks	36,000,000
For the Lower Cambrian rocks	6,000,000
	704,235,000

These chronological results Mr. Goodchild offers only as a rough approximation to the real truth, not by any means as a final answer to a difficult question. The seven-hundred-million years carry us back to the beginning of the Cambrian Period, but not to the commencement of life on the Earth. The Lower-Cambrian fauna already contained representatives of all the chief forms of Invertebrate life; and probably the earliest preceding organisms existed as far away from that period as that period is from the present.

II.—Geological Map of the British Isles. (Edinburgh and London: W. and A. K. Johnston, 1896.)

THIS map, originally compiled by Sir Archibald Geikie, LL.D., etc., Director-General of the Geological Survey of Great Britain, has been revised and extended by Alex. Johnstone, F.G.S., etc. It is on the scale of 1,890,000 of nature, or fourteen miles to an inch. It is an excellent wall-map in its general aspect; and at the same time is plentifully inscribed, in small writing, along the coastlines with geological and mineralogical notes relating to the interior.

This new edition of the Geological Map of the British Isles, to which the "Mineralogical Geology" noticed on p. 418 is an adjunct, gives the systematic groups of formations in their several areas, strongly coloured and distinctly indicated by successive numbers. The grouping we give below. As many of the subdivisions are included in the general hard and fast colour of the group, their individuality is lost in the map, although often traceable in one or the other of the forty-five sections (either diagrammatic or generalized), which usefully occupy available spaces on the map-sheet.

The Quaternary (24, 23) is not mapped. 22, Pliocene or Crag. (21, Miocene, absent.) 22, Oligocene. 19, Upper and Middle; and 18, Lower Eocene. 17, Upper; and 16, Lower Cretaceous. 15, Upper, Middle, and Lower Oolite. 14, Lias. 13, Triassic, including Rhætic. 12, Permian (a dark-brown, printed inadvertently in two tints, above and below the latitude of Hartlepool). 11, Coal-measures. 10, Millstone Grit and Devonshire Culm. 9, Carboniferous Limestone Series. 8, Upper Devonian and Upper Old Red Sandstone. 7, Middle Devonian. 6, Lower Devonian and Lower Old Red Sandstone. 5, Silurian. 4, Ordovician. 3, Cambrian. 2, Newer Pre-Cambrian and Archæan, or Huronian. 1, Older Pre-Cambrian and Archæan, or Laurentian. If it were not for their numbering, some of the colours would probably be mistaken on the map one for another—such as 20, 19, 18, and 8, 7, 6; also 11 and 4.

Some extra care has been taken in the definition of the Igneous Rocks both on the map and in the explanatory list with the "Table of Systems and Formations," thus:—Acidic: granite, G; syenite, S; felsite, F; trachyte, T; obsidian and pitchstone, P. Intermediate: diorite, D; andesite, A; lamprophyre, L; and phonolite. Basic: dolerite and basalt, B; gabbro, Gb; picrite, Pc; serpentine, Sr; and tachylite.

This map will be found very useful in lecture-room, study, and hall.

III.—Mineralogical Geology: A Synopsis for the use of Students; to accompany W. and A. K. Johnston's Geological Map of the British Isles. By Alexander Johnstone, F.G.S. 8vo; pp. 194, with 12 plates of fossils. (Edinburgh and London: W. & A. K. Johnston, 1897. Price 3*s.* 6*d.* separate; or 23*s.* 6*d.* with the Map, which is reviewed on p. 417.)

THE Geological Magazine for March, 1865, contained a notice of the "Outlines of the Geology of the British Isles," accompanying Johnston's Geological Map. Since then our knowledge of the geological details has been improved by the Geological Surveyors and others, for the newer editions of the map; and the study of rock-structure, or lithology, has increased so widely and earnestly that it has become as necessary as palæontology for the right interpretation of the succession of strata, their relative age and modes of origin. Of course a knowledge of mineralogy must precede a perfect acquaintance with the structure of rocks; and, indeed, the earlier geologists thought more of minerals than of fossils.

The author states that, as the distribution of minerals is not shown on the Geological Map, he has thought it well to devote this book specially to the consideration of the mineral side of the science. He proceeds to a systematic treatment, first, of the common *elements*, and, secondly, of the common *compounds*, occurring in the crust of the Earth; and then advances to the exposition of mineralogy, including crystallography. For the character and conditions of minerals, pages 15–110 are apportioned. Systematized descriptions, with useful tables for comparisons and contrasts, give full details of each property, feature, and condition; microscopic treatment being referred to when necessary.

In Section III, pages 110–179, is given an alphabetical catalogue of the most important minerals, with concise notes as to their chief characters and their British localities. A Table of the Igneous Rocks succeeds (pp. 180–191); useful both in general and special aspects. The Aqueous and Metamorphic Rocks are succinctly tabulated.

Fossils, after all, are not neglected. A neat table shows the range-in-time of the most important animal forms, as they occur in the successive geological systems or formations; and is accompanied by twelve plates illustrative, to some extent, of the several zoological groups, from the Corals upwards, for the Palæozoic, Secondary, Tertiary, and Quaternary systems.

There is altogether a great store of mineralogical information, compendious, well-planned, and easily got at, in this valuable little book; besides its condensed and illustrated palæontological appendix. Probably, however, the students for whom this "Mineralogical Geology" seems to have been specially intended would wish that the plates had figures of minerals and rock-structures as well as fossils.

IV.—The Rocks and Soils of Grenada and Carriacou and the Agricultural Chemistry of Cacao. By J. B. Harrison, M.A., F.G.S., Government Analyst of British Guiana. 60 pages. (London: Waterlow & Sons.)

ALTHOUGH, in the main, a treatise on agricultural chemistry, this paper contains many facts of interest to the geologist. The author states that the island of Grenada, the most southerly of the Windward Group, "is purely volcanic in its origin, the only signs of upheaval being raised limestone beaches towards the extreme north." He regards it as being of more ancient date than many other of the islands of the same group. The configuration has been largely determined by denudation, and it is now difficult to fix the exact sites of the ancient craters. The lavas collected by the author during his comparatively short stay on the island comprise hornblende-andesite, hornblende-augite-andesite, augite-enstatite-andesite, augite-andesite with olivine and olivine-basalt. Full analyses of most of these rocks are given.

The soils of the island have been derived either from the lavas or from fragmental rocks of similar composition. Analyses of forty-one examples of the Grenada soils are given, and suggestions are made as to the methods by which many of these soils may be improved. The author also discusses the relations between the soils and the rocks from which they have been derived. He compares the analyses of soils derived from hornblende-andesite and from olivine-basalt (including olivine-bearing augite-andesite) with the fuller analyses of the rocks, and draws conclusions as to the relative proportions of the different constituents removed during the process of soil-formation. He takes as the basis of his calculation the assumption that alumina is not removed; and arrives at the conclusion that in one case an increase of thirty per cent. of iron-oxide has occurred. Now this may be almost said to be an impossible result. It indicates, as the author himself suggests, that alumina has been removed. A better result would probably have been attained by assuming that the total amount of iron-oxides remained constant. As the point is an interesting one, let us take the author's figures and recalculate on this basis.

	Hornblende-andesite.	Soil derived from Hornblende-andesite.	Loss.	Percentage of each constituent lost.
SiO_2	62·74	33·98	49·32	78·62
ZiO_2	trace	—	—	—
Al_2O_3	13·67	24·89	3·84	27·87
Fe_2O_3	3·39	16·98	—	—
FeO	4·35	2·63		
MnO	·42	·28	·31	73·34
CaO	6·01	2·48	5·03	84·68
MgO	1·74	2·28	·88	50·61
K_2O	1·23	·25	1·13	91·82
Na_2O	4·25	1·35	3·71	87·43
P_2O_5	·18	·14	·12	68·01
SO_3	—	·04	—	—
CO_2	—	·15	—	—
H_2O etc.	2·02	14·55	—	—
	100·00	100·00	64·34	

From this it appears that at least sixty-four per cent. of the original material has been carried away, including seventy-eight per cent. of the silica originally present, twenty-seven per cent. of the alumina, eighty-four of the lime, ninety-one of the potash, and eighty-seven of the soda. These results are somewhat surprising, but they cannot be said to be impossible. They depend only on the assumption that the material analyzed was a fair sample of the soil formed from the hornblende-andesite, and that no iron has been removed. If iron has also been carried away, the actual amount of material lost will, of course, be greater than that indicated by the calculation.

The author was unable to examine the upraised limestones on the west coast near Mount Nesbit, but specimens from this locality were submitted to him. "These were found to consist of a shallow-water foraminiferal limestone, the most common foraminifer present being *Amphistegina*. Fragments of corals, shells, and of spines of echinoderms were also present." At the extreme north-west of the island the author himself observed beds of coral sand and mud at heights of 150 or 160 feet above sea-level.

His visit to Carriacou, though brief, gave results of great interest, and we quote his description at almost full length. "The island appears to be in the main composed of beds of fine-grained volcanic sands and tuffs. Near the town of Hillsborough, on the road towards Dumfries, I noticed a little exposure of what was either a compact tuff or a much altered lava, but I did not notice a similar rock elsewhere. As, however, I was not able to visit High North Hill and Chapeau Carré, I cannot form any definite opinion as to whether or not compact lavas occur in Carriacou. On the eastern slopes of the island, and at Belair, at an altitude of 600 feet, the tuffs of which the hills are composed are covered with layers, from ten to twenty inches in thickness, of a shallow-water foraminiferal limestone, which, upon microscopical examination, was found to be made up principally of *Amphisteginæ* and organisms apparently the remains of calcareous algæ. As far, therefore, as I was able to examine Carriacou, it appears to consist of layers of volcanic ashes, which were deposited in the sea, and afterwards covered with a foraminiferal shallow-water limestone. Later this was subjected to upheaval, with the result that part of the limestone was raised to at least 600 feet above the sea-level."

The concluding part of the work deals with the agricultural chemistry of Cacao. We hope that Mr. Harrison will be able to find the time to continue his most interesting geological observations on the West Indian Islands, for he possesses qualifications which are not often combined in the person of one observer.

V.—On the Origin of the European Fauna. By R. F. Scharff, Ph.D., B.Sc., F.Z.S., Keeper of the Natural History Collections in the Dublin Museum of Science and Art. Proc. Roy. Irish Acad., 3rd ser., vol. iv, No. 3, 1897, pp. 427–514. 8vo. (Dublin, 1897.)

THIS is a most important and instructive memoir, and full of very valuable facts; but the author has not always been able to arrange them in such a happy order that the reader may find his way

readily through the great mass of materials which is here placed before him, even though aided by the headings of the chapters and sections and the general summary which the author has given (on pp. 502–506).

We venture to suggest that the title, "On the Origin of the European Fauna," is scarcely appropriate; the Memoir might more properly be described as an enlarged and improved edition of Dr. Scharff's earlier paper, "On the Origin of the Irish Land and Fresh-water Fauna" (Proc. Roy. Irish Acad., 3rd ser., vol. iii, 1894). Indeed, in the introduction of the present paper (p. 428) the author says: "As the origin of the Irish fauna forms the key to the solution of the problem which I propose to discuss, I intend to deal with it more fully than has been done, before entering on the larger subject of the general European fauna." The larger subject is, however, dealt with in a very summary and subordinate manner, and we find that Ireland really takes the "leading lady's" part. What the author calls "the *Southern migration*," meaning a migration *from* the south—and which really refers throughout specially to the British Islands, and more particularly to Ireland—has in many cases been rather a migration *to* the south, and in other cases no migration at all.

The Lusitanian element in the flora and fauna of Ireland, etc., dates probably from the Miocene. Again, a certain percentage of European Pleistocene and recent mammals have been members of the European fauna from Tertiary times, and if they migrated at all they migrated southwards. For example: The small dormouse, *Muscardinus avellanarius* (p. 479), is met with in a very little modified form in the Middle Miocene of Europe; the negative fact of its being absent nowadays from Ireland proves nothing at all.

Myogale moschata (p. 447), believed to have migrated to Great Britain from Siberia, has nothing to do with Siberia. It inhabits to-day *Southern* or rather South-Eastern Russia, and has been found in the Norfolk Forest-bed (Mem. Geol. Surv. 1882: "The Vertebrata of the Forest-Bed Series," pp. 98–102, pl. xvi, figs. 1–10; by E. T. Newton, F.R.S.), and a very closely allied form occurs in the Middle Miocene of Sansan and La Grive.

Again: Hippopotamus and Hyænas were already in Europe in Pliocene times, and remained there during part of the Pleistocene period, adapting themselves, as long as they were able, to the changed conditions of climate and environments.

But—apologizing for this digression—Dr. Scharff must now be allowed to speak for himself, and he is well qualified to do so.

The Divisions of the Irish Terrestrial Fauna.—"A careful study of any section of the Irish fauna and flora reveals the fact that there are in it minor groups of animals or plants which on the Continent live altogether in the north, some which inhabit exclusively the south, and others again to which no particular limit of range can be assigned. Besides these there are a small number of species peculiar to Ireland, which we need not consider here.

Taking the fauna as a whole, we find that we can establish three distinct divisions as follows :—

I. Animals with a wide distribution.
II. Animals with a Northern distribution.
III. Animals with a Southern distribution.

"I. Those of the first division comprise all animals whose origin is obscure. Many of them may, at some time or other, have been introduced by man, such as the rat or the mouse. The majority, however, I think, are of great antiquity, and their origin dates from some remote geological age. They appear to be mostly indifferent to changes of temperature, and many thrive equally well in cold and in hot countries. The small brown slug (*Agriolimax lævis*), the painted lady butterfly (*Vanessa cardui*), and the barn owl (*Strix flammea*) are familiar examples.

"II. To the animals of the second division belong those of which we have distinct evidence, from their geographical range, that they are of Arctic origin. As I hope to prove later on, they have arrived in Ireland directly from the north. Among the mammals the reindeer (*Rangifer tarandus*, Linn.), which formerly inhabited this country, the Irish stoat, and the Irish hare form part of this northern section. The beetles *Pelophila borealis* and *Blethisa multipunctata*, the butterfly *Cœnonympha typhon*, the small shell *Vertigo alpestris*, as well as the common stickleback (*Gasterosteus aculeatus*), have all reached Ireland from the north.[1]

"III. The third division includes the bulk of the Irish fauna. In the first place, we have to consider those animals whose birthplace appears to be in South-Western Europe, then we have those which originated in the South or South-Central Europe, whilst there are others which came to Ireland from the south-west, though they may primarily have migrated there from Central Asia across Southern Europe. No very strict line can be drawn between the animals of South-Central and those of South-Western European origin, but we may with Edward Forbes[2] regard the most southern as the oldest. A good many of these are altogether absent from England, whilst they are mostly confined to the west coast in Ireland. Taking all the Irish southern types into account, we find that the majority are confined, in the remainder of the British Isles, to the south-western parts of England and Wales. In some cases they appear again in the extreme north of England and in Scotland, without, however, being known in the intermediate tracts.

"We can subdivide this southern fauna, therefore, into a south-western and a south-central one: to the former belong the well-known bullfinch (*Pyrrhula Europæa*), the dipper (*Cinclus aquaticus*), and the natterjack toad (*Bufo calamita*); also the following

[1] Among the Irish plants we have some species, such as *Spiranthes Romanzoviana*, *Eriocaulon septangulare*, and *Sisyrhynchium angustifolium*, which appear to belong to the same division.

[2] "The Connection between the Distribution of the existing Fauna and Flora of the British Isles with the Geological Changes which have affected their area": Mem. Geol. Surv., vol. i, 1846.

Mollusca, *Geomalacus maculosus*, *Pupa Anglica*, *Helix fusca*, and *H. pisana*; the beetles, *Rhopalomesites Tardyi*, *Eurynebria complanata*, and *Otiorrhynchus auropunctatus*. Among the Irish woodlice, *Platyarthrus Hoffmanseggii* belongs to this first division, as well as the Hemipteron *Lygus atomarius* and the millipede *Polydesmus Gallicus*. Some of the species peculiar to Ireland have their nearest relatives confined to the south-west of Europe, e.g. *Tegenaria Hibernica*, which is closely related to the Pyrenean *Tegenaria larva*.[1]

"The badger (*Meles taxus*), is for our purposes a South European type of the second subdivision, though it originated probably in Asia. The following Mollusca also belong here: *Helix aculeata*, *H. rufescens*, *H. virgata*, *H. acuta*, *H. nemoralis*, and many others; also the beetle *Strangalia aurulenta*."[2] (p. 430.)

On the Accidental Dispersal of Animals and Plants.—Referring to the accidental means of dispersal of animals and plants Dr. Scharff observes (p. 434): "As regards Ireland, I believe the animals derived from accidental or occasional means of dispersal amount to five per cent. of the whole fauna at the most. Land and freshwater mollusca are generally looked upon as particularly liable to accidental dispersal." After quoting the experiment of Baron Aucapitaine, who, having immersed living *Cyclostoma elegans* for a fortnight in the sea, found that almost all of them survived, he adds: "Supposing Ireland had been stocked in this manner with (land-)shells, we should expect operculate species, or even such which provide themselves with a membranous diaphragm during winter to be abundant. But this is not the case. Neither *Cyclostoma elegans* nor *Helix pomatia*, the two species which were experimented on, inhabit Ireland, though both occur in England and in France. Moreover, as a matter of fact, the shells of the former species have again and again been washed ashore within recent years upon the Irish coast; but though this must have been going on for centuries, yet *Cyclostoma elegans* has not established itself in this country. The only Irish operculate land-shell (*Acme lineata*) lives permanently underground, and is therefore less liable to accidental transportal than the other species."

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"It is fully admitted that many animals and plants are easily transported to new countries by accidental means, or voluntarily by man, but in most cases they have not been able to retain a permanent footing in their newly-adopted home. There are innumerable instances on record of species having been planted on spots where they did not previously exist, and the introducers claim that it is highly interesting to watch their progress. In the great majority of cases we find that, fortunately, these species utterly vanish after a few years." (p. 435.)

[1] The following Irish plants may be mentioned: *Arbutus unedo*, *Euphorbia Hiberna*, *Simethis bicolor*, and *Sibthorpia Europea*.

[2] *Cotyledon umbilicus*, and other plants, probably belong to this type.

"These few instances will suffice to show that it is by no means so easy as it is generally supposed, to establish an animal in an area which it was previously not known to inhabit, and that really only a very small percentage of the Irish fauna can be due to an occasional means of dispersal." (p. 436.)

On the former Land-connection between the British Isles and the Continent.—After citing numerous authors on the former land-connection between the British Islands and the Continent, the author remarks:—"It is difficult enough to imagine how, under the present configuration of Ireland, the mammoth, the wolf, and the bear reached the island. But when we come to the less conspicuous Invertebrates, we are confronted with cases which give us even less chance of escaping from the inevitable assumption of a land-connection with the Continent. How are we, for instance, to suppose that earth-worms reached Ireland, or *Testacella*, a slug-like mollusc, which spends its entire existence under ground, or *Platyarthrus Hoffmanseggii*, a blind wood-louse, which also lives below the surface of the soil, in the nests of ants, unless by slow migration on land?" (p. 438.)

Having decided that the bulk of the Irish fauna migrated to Ireland on land, the author proceeds to consider what was the nature of that land-connection, and by means of a diagram he shows that the old land-surface of the British Isles embraced the entire extent of the coast platform to the 100-fathom line from the Shetlands, Orkneys, and the Western Isles to the coast of France south of Belle Isle.

The Lusitanian Flora.—Dr. Scharff points out that the Lusitanian flora and fauna are not peculiar to Ireland. "Fragments of it occur undoubtedly in the south-west of England, in the Channel Islands, and along the west coast of France. That flora migrated, therefore, along the ancient sea-border from the south, across the south-west of England, or the land that lay beyond it." (p. 440.)

The Northern Immigration of Plants and Animals.—"The northern animals and plants undoubtedly came across from Scotland, and in the county of Londonderry, which part of modern Ireland they first touched, they still are more common than in any other portion of the country. But they did not originate in Scotland. . . . . It was from Scandinavia that our northern animals and plants came. Many of them, possibly, originated there, but the home of others lies, no doubt, far beyond even the confines of Scandinavia in the Arctic regions. Thus Ireland had, as we have seen, two land-connections with the Continent of Europe—one by way of the south of England to France, and the other by way of Scotland to Scandinavia."

Effect of the Glacial Period on the Pre-existing Fauna and Flora.—After quoting the views of extreme glacialists who hold that in the Glacial period the cold was so intense that all life was exterminated, the author adds—"The evidence as to the existence, however, of a fauna in Southern England, at any rate during the Glacial Period, is so overwhelming, that I can hardly believe that many naturalists will accept Professor Geikie's views. Nevertheless, there

are certainly some who do, and among them Mr. Clement Reid, author of the 'British Pliocene Deposits,' who remarks that 'in the Britain of the present day we may study the repeopling of a country over which everything had been exterminated!' . . . . The opinions expressed by zoologists, botanists, and geologists are overwhelmingly in favour of the Post-Glacial age of the present British fauna. It is believed, even by most of those who admit that the British Islands were inhabited by a very similar fauna and flora in Pre-Glacial times, that a vast destruction of animal and vegetable life took place during the Pleistocene epoch, and that very few, if any, species survived the change of climate brought about by the Glacial period." "As I have already indicated," says Dr. Scharff, "I do not share these views." The author then proceeds to give his own conclusions on this point.

Geographical Conditions prior to the Glacial Period.—"At the commencement of the latter half of the Pliocene epoch, or we might say about the time of the deposition of the Red Crag, the Atlantic was closed in the north by a continuous land-connection between Northern Scandinavia, Spitzbergen, Franz Joseph's Land, Northern Greenland, and Arctic North America. The Pacific was likewise separated from the Arctic Ocean by a land-barrier between Alaska and Kamtschatka. The Arctic fauna and flora were thus enabled to spread into Northern Europe and North America. England was also connected with France and Ireland, and Scandinavia and Ireland with Scotland. A marine expansion from the White Sea then spread across Northern Russia into the North European plains, and the sea thus formed, which I proposeto call the North European Sea, joined the united basins of the Aralo-Caspian and Black Seas." (p. 445.)

Movements of the Faunas and Floras.—"The Siberian fauna was, therefore (at that time) unable to enter Europe, while the more southern Central Asiatic fauna continued to migrate into Southern Europe, as in Miocene and early Pliocene times, by a land-connection which joined Asia Minor and Greece. A gradual retreat of the North European Sea to the north opened up a passage in Eastern Europe by which the Siberian fauna poured into Central Russia, Germany, France, and England. There is distinct geological evidence that this vast migration of the Siberian fauna and flora occurred after the deposition of the Lower Continental Boulder-clay. The advance-guard composed of mammals arrived in England during the deposition of the Forest-bed. This marks, therefore, not only the time of the first retreat of the North European Glacial Sea, but also that of the disconnection of England and Ireland, since none of the Siberian mammals entered the latter.

"Meanwhile the Central and South Asiatic mammals, which, as I mentioned, had rambled into Southern Europe, spread into Northern Africa and Western Europe along the shores of the Mediterranean. Many subsequently invaded Central Europe, and also spread north into Great Britain and Ireland. These and the Arctic mammals mostly retired before the Siberian invaders. Hence the purely

Arctic species had also reached Western and Central Europe before the advent of the latter." (p. 445.)

"In speaking of the Irish Arctic fauna, we must not, as so many naturalists have done, confuse animals of an Arctic with those of a Siberian origin. It is very important to distinguish these two elements, both of which are present in the fauna of Great Britain, though only the former has reached Ireland."

Siberian Mammals in Britain.—"In order to show the importance of the Siberian element in the English fauna, I will give a list of the species of the mammals which have migrated to Great Britain from Siberia, marking those with an * which still exist or only became extinct in historic times in the country. There is no reason to suppose that any of the latter became extinct and have since been reintroduced.

SIBERIAN MIGRANTS.

Canis lagopus.
Gulo luscus.
**Mustela erminea.*
**M. putorius.*
**M. vulgaris.*
**Sorex vulgaris.*
(? *Myogale moschata*).[1]
Lepus diluvianus.
**L. Europæus.*
Lagomys pusillus.
**Castor fiber.*
Cricetus songarus.
Sphermophilus Eversmanni.
S. erythrogenoides.
Myodes lemmus.
Myodes torquatus.
**Mus minutus.*
**Arvicola agrestis.*
**A. amphibius.*
A. arvalis.
**A. glareolus.*
A. gregalis.
A. ratticeps.
Equus caballus.
Antilope saiga.
Ovibos moschatus.
Alces latifrons.
A. machlis.
Rangifer tarandus.

"We have geological evidence that most of these twenty-nine species of mammals emigrated from Siberia to Europe across the Steppes of Southern Russia. Along with them came a large number of other forms of life, and also plants; and as we advance eastward from England, we meet with them in increasing numbers to the present day. But not only on the Continent do we find these survivals of the vast Siberian migration, which has been so ably described by Professor Nehring[2]; no less than ten species still live in Great Britain (including the recently extinct beaver). On the other hand, not more than three of the species mentioned on the list above have been found fossil in Ireland, and only one still survives. It should be remembered that these three species, viz., *Mustela erminea*, *Equus caballus*, and *Rangifer tarandus*, occur in Ireland in varieties distinct from those found in Central Europe; and on this and other grounds, I believe that they came by a different route from those found in England, and that Ireland was not connected with England at the time of the arrival of the Siberian emigrants in the latter country." (p. 448.)

[1] *Myogale moschata* should be removed from this list; it belongs to South-Eastern Russia (see remarks on p. 421, ante).

[2] "Geographische Verbeitung d. Säugethiere in dem Tschernosem Gebeite," etc. 1891.

"We have still to inquire into the causes which led to the Siberian migration, and to ascertain the geological period during which it took place. In order to arrive at a more satisfactory conclusion on these problems, it is of some moment to study the extinct fauna of Siberia." (p. 449.)

"Since Tcherski has shown that Western Siberia is largely covered by fresh-water deposits, the assumption that the Aralo-Caspian had been in direct communication with the Arctic Ocean as recently as the Pliocene epoch can no longer be maintained; but, as we shall see presently, there is some evidence in favour of a European connection between the two seas." (p. 453.)

(*To be continued in our next Number.*)

CORRESPONDENCE.

TRESPASSERS, BEWARE!

SIR,—I am grateful to my "kalikali" colleague, Mr. F. A. Bather, for pointing out that (in common with the more learned palæontologists who have recently prepared a Synopsis and a Revision of the Cystoidea) I had overlooked the fact of a new name having been proposed for Hall's *Echinocystis* in the last edition of his friend Mr. S. A. Miller's Catalogue.

In regard to *Discocystis*, a defence of the name would involve a greater trespass into the domain of the Cystoidea than I was recently forced to make in relieving the term *Echinodiscus* from double duty in Echinoderm nomenclature. A review in the current number of *Natural Science* helps me to resist the temptation; for the reviewer, whose information is apparently of the best, deplores the brief treatment of the Cystoidea in the new Guide to the Fossil Invertebrata in the British Museum, although "our National Museum possesses not only a fine collection of those rarities, but an officer well qualified to deal with them." J. W. GREGORY.

TRINUCLEUS SETICORNIS.

SIR,—It is satisfactory and instructive to find in last month's GEOLOGICAL MAGAZINE Mr. Marr so clearly indicating his early mistake about the range of *Trinucleus seticornis*, for he mentions in his criticism of my remarks that in 1883 he had stated that this species was nowhere found in the Upper Bala, while in 1885 he was led to call some Upper Bala beds in South Wales the *T. seticornis* beds, on account of its abundance in them. After this presumably conscious acknowledgment of an error, I am, therefore, surprised to find Mr. Marr much troubled in mind because I naturally considered that his statement of 1885 considerably qualified, or even negatived, his earlier one of 1883. Perhaps Mr. Marr wishes to make another correction in his opinions published in 1885.

With regard to the identification of this protean species of trilobite I exceedingly regret that infallibility cannot be claimed as a prerogative by eminent geologists, or even by "very competent palæontologists," at any time of their life, and that consequently Mr. Marr

and I have to suffer for their sins and misfortunes in failing to examine or understand Hisinger's type. It is to be hoped that we shall not have to suffer more in this or any other respect by the labours of the new "very competent palæontologist" to whom Mr. Marr refers.

But with regard to the right or wrong determination of this species of *Trinucleus* I can speak with a very much freer conscience than Mr. Marr, for the genus so far seems conspicuous by its absence from the Keisley Limestone (as I have stated in my paper which Mr. Marr criticizes), and therefore I have had no question of its specific identification to decide for myself in this case. Mr. Marr, therefore, appears to have been singularly unlucky in his choice of a weapon with which to attack my conclusions, and it is a pity his solicitude for the readers of this Magazine has led him to omit his criticisms on the "many statements" and "questions of detail" in my paper with which he disagrees.

F. R. Cowper Reed.

Cambridge, *August* 16, 1897.

OBITUARY.

SIR AUGUSTUS WOLLASTON FRANKS, K.C.B., ETC.

Born 1826. Died May 21, 1897.

Sir Augustus Wollaston Franks, K.C.B., D.C.L., F.R.S., Pres.S.A., F.G.S., Trustee of the British Museum, late Keeper of British and Mediæval Antiquities and of Ethnography at the British Museum, was born at Geneva in 1826, and educated at Eton and Trinity College, Cambridge, taking his M.A. degree in 1852. His taste for the beautiful in works of art, and his appreciation of the niceties, peculiarities, and fantasies of artists, whether the results were produced with the inspiration of genius or by handicraft and labour, led him to collect largely in each department of artistic work, and fortunately his ample means enabled him to do so. With munificent liberality he gave many valuable collections to the National Museum at Bloomsbury. It was thus that, not only theoretically, but practically and personally, he was acquainted with the extensive and many-sided collections of antiquities and ethnographic exhibits under his keepership. He was not a mere official custodian, but a cultured connoisseur, and a high-class authority on all points connected with the scientific and historical aspects of the materials or collections in his charge. Necessarily his study of mediæval remains kept him in touch with those of prehistoric age in the British Collection which was under his care; and, indeed, of these there are many objects of human workmanship dating from extremely early times. Contemporary with these were similar productions in European and other countries. These are largely represented in the British Museum by the "Christy Collection," which Sir Wollaston Franks augmented by successive gifts of similar well-assorted examples from many localities. Indeed, this notable department in the Museum well deserves now to be called the "Christy-Franks Collection."

In March, 1864, Mr. Henry Christy invited a party of his friends, interested as antiquaries and geologists, to examine some of the bone-caves on the Vezère, Dordogne district, in the south of France, which, with his friend Edouard Lartet, he had for some time been investigating with great care and at considerable expense. The party comprised Mr. W. J. Hamilton (President of the Geological Society), Professor Rupert Jones (Assistant Secretary of the Geological Society), Sir Douglas Galton, Sir John Lubbock, Sir John Evans, and Sir A. W. Franks.[1] Not only had the last-named already interested himself in Henry Christy's researches in the ethnographic relationship of various textile fabrics, which had led him to Mexico, and in that country to the observation of stone implements, but Sir A. W. Franks heartily joined Christy in the study of stone implements, and of those who made and used them, whether ancient peoples, recent savages, or living workmen in some modern trades and manufactures. Together with Dr. Hugh Falconer, he aided H. Christy and E. Lartet in planning their great work, "Reliquiæ Aquitanicæ," which was intended to comprise descriptions of all the Dordogne caves and their contents. Unfortunately the death of both Christy and Lartet circumscribed the work within smaller limits, for no more caves were worked out by them, and but few plates were subsequently added to the eighty or more already lithographed for its illustration. It is noticed, we see, in the preface of the book that, "In bringing together and arranging the varied materials supplied by friends at home and abroad desirous of making the 'Reliquiæ Aquitanicæ' useful in Archæology and Anthropology, the directing counsels of Mr. A. W. Franks, F.R.S., have been constant and efficient, like his courtesy and knowledge."

He took charge of the "Christy Collection" at 103, Victoria Street, S.W., for some time before it was transferred to the British Museum; and he individualized the specimens with accurate drawings by his talented assistants—first, Mr. T. K. Gay and subsequently Mr. Charles Read. The latter worthily succeeded Sir Wollaston on his resignation, in 1894, as Keeper of British and Mediæval Antiquities and Ethnography in the British Museum.

It was with great caution that Sir Wollaston exercised his judgment as to the authenticity of implements of stone and their relative age. He was not an enthusiast in the subject of the great antiquity of the Human Race. Possibly, had he been induced to give more leisure to the study of the geological aspect and details of the subject, he might have become cognisant of the value of Sir Joseph Prestwich's researches in the geological age of some of the older groups of flint implements, especially of those collected with earnest and intelligent care at Ightham, in Kent, by Mr. Benjamin Harrison.[2]

Sir A. Wollaston Franks contributed largely to scientific literature, especially by memoirs and notices in the Transactions and Proceedings

[1] Quart. Journ. Geol. Soc., vol. xx, 1864, p. 444; and "Reliquiæ Aquitanicæ," part xii, 1873, p. 161.

[2] See Quart. Journ. Geol. Soc., xlv, 1889, pp. 270–297, pls. ix–xi; and Natural Science, vol. v, p. 269, Oct. 1894.

of learned societies. He has greatly enlarged the knowledge of antiquities and their real relationships, not only by original research, but by his willing advice and ready information to inquirers, whether in London or the provinces. He has bequeathed all his most valuable collections to the British Museum. He was elected to the Royal Society in 1854. For many years an active and valued Fellow of the Society of Antiquaries, he was elected Director of the Society in 1858; subsequently for some years he was Vice-President, and eventually became President in 1892. T. R. J.

SAMUEL ALLPORT, F.G.S.

Born January 23, 1816. Died July 7, 1897.

By the death of Mr. Samuel Allport we have lost one of the pioneers in microscopic petrology. He was born at Birmingham on January 23, 1816, being descended from an old Staffordshire family, and was educated at King Edward's School in that town. For some years he was in the office of Rabone Brothers, and then went to Bahia in South America as business manager for another firm. There he married a Spanish lady, but had the misfortune to lose his wife within a year. On his return to England, after an absence of eight years, he took a share in a business on Snow Hill, and devoted all his spare time to scientific work. He had already become an ardent geologist, and his first paper, published in the Quarterly Journal of the Geological Society for the year 1860, was on the discovery of some fossil remains near Bahia (vol. xvi, p. 263). But he was quick to perceive the importance of studying the structure of rocks by the method which a few years before had been initiated by Dr. Clifton Sorby. He prepared his own specimens, and acquired such skill that in the writer's opinion, though he may have been equalled, he has never been surpassed in this craft by any English worker. In course of time he formed a large collection of both rock-specimens and microscopic slides, to the study of which he devoted himself with great energy. The business in which he was a partner unfortunately was not prosperous, and had to be abandoned about 1880, when he was appointed librarian to the Mason College. Though circumstances had compelled him to sell his collection some little time before to the British Museum, he set to work energetically to form another, and continued at his favourite study. But now health began to fail; any continuous mental exertion brought on distressing attacks of vertigo, and in 1887 he was obliged to retire from his post at the Mason College. After this, though he was still able to continue his geological reading, and to work quietly with his microscope, he was unfit to bear the strain of writing a paper. His last effort, a valuable report on the effect of Contact Metamorphism exhibited by the Silurian Rocks near the town of New Galloway (Proc. Roy. Soc., xlvi, 193), could not have appeared without collaboration. Increasing ill-health and grave anxieties unhappily cast a shadow over Allport's later years, but all was endured with quiet patience and gentle fortitude. Some three years ago he quitted Birmingham for Cheltenham, where

he died after a very short illness on July 7, his mind happily remaining unclouded till near the end.

Allport was not a voluminous writer. He published rather less than twenty papers in all, most of which appeared in this Magazine, or in the Quarterly Journal of the Geological Society. In the former those on the South Staffordshire Basalts (1869), the Wolf Rock Phonolite (1871), and the Pitchstones of Arran (1872) may be specially mentioned; in the latter the highly important papers on the British Carboniferous Dolerites (1874), on the Metamorphic Rocks surrounding the Land's End Granite (1876), on devitrified Pitchstones and Perlites from Shropshire (1877), and on the Diorites from the Warwickshire Coalfield (1879). He became a Fellow of the Geological Society in 1869, was awarded the Wollaston Fund in 1879, and received the Lyell Medal in 1887.

We cannot measure the value of Allport's work by its quantity. His extreme care as an observer, alike in the field and with the microscope, his wide range of knowledge, for he was far more than a petrologist, his strictly inductive habit of mind, give to that work exceptional solidity and permanent value. Though he was compelled to feel his way, as a man in an unknown forest, he was one of the safest of guides. To such a patient, accurate observer and sound, cautious reasoner, flashy hypotheses presented no charms, and Samuel Allport did much to liberate petrology from such errors as making geological age a factor of importance in the classification of igneous rocks. Amiable, courteous, and openhanded, he was beloved by those who had the good fortune to know him. Absolutely free from all petty jealousies, he was the most generous of helpers to all younger men who were attracted to his favourite study. Whatever he knew was at the service of others, and no man owes him a deeper debt of gratitude than the writer of this tribute to his memory. T. G. B.

PROFESSOR S. A. B. LUNDGREN.

Born February 19, 1843. Died January 7, 1897.

The death of Professor Lundgren has removed from Sweden a valued worker in the field of geological science, and in him the University of Lund has lost one of its most energetic and able lecturers.

Sven Anders Bernhard Lundgren was born at Malmö in Scania on the 19th of February, 1843. He seems to have passed the early days of his life in his native town, but became a student at the University of Lund in the autumn of 1860.

He worked diligently at all the subjects then considered essential for the degree in Philosophy, but at an early stage in his career he showed a marked preference for natural science. He especially distinguished himself in zoology and botany, and was a very fair chemist.

Geology was not at that time recognized as a distinct subject in the examinations of the University; nevertheless, Lundgren attended some lectures on that subject given by N. P. Angelin. He took his

examination for the degree of "Kandidat" in 1864, and proceeded to the final degree of Doctor in Philosophy in the following year. The treatise that he wrote for this occasion was on a geological subject, namely, "A contribution to the knowledge of the geological relations of the Saltholm Limestone."

The following September Lundgren accompanied Professor E. Hébert on a geological tour in the Scanian Mesozoic districts. It was in this trip that he made his first acquaintance with the district whose geology was to be the subject of his most important work.

From that time he appears to have turned his attention to geology entirely, and in June, 1867, was appointed "docent" in Palæontology. At this time the Professorship of Zoology at Lund was taken to include that of geology, and was held by Professor Otto Torell, the present chief of the Swedish Geological Survey. When Professor Torell vacated the Chair of Zoology in 1880 the two professorships were separated, and Lundgren was appointed first Geological Professor in the University of Lund. Previous to receiving this appointment he had made several journeys abroad, and had become thoroughly acquainted with the Mesozoic Geology of Western Europe. Of Lundgren's activity as a teacher in the University of Lund little need be said; the very existence of the Geological Institute will remain as a lasting memorial of his untiring zeal and devotion to the cause of his favourite science.

As a lecturer he seems to have had a wonderful power of interesting his audience in his subject, partly, no doubt, because he could speak of most important matters from personal observation.

His best known geological works are those which treat of the Mesozoic Rocks of Scania, and it must not be forgotten that it is to Lundgren that we are indebted for the working out of the highest Cretaceous (Danian and Senonian) beds of the South of Sweden, and he also showed the true relation of the Saltholm Limestone to the Faxoe Limestone. Another great work of his was published in 1885 "On the Brachiopoda of the Swedish Chalk." Among other papers was "A treatise on the Mollusca in the older Swedish Mesozoic Deposits," published in 1881, and the third part of the well-known "List of the Fossil Faunas of Sweden." This part dealt with the fauna of the Swedish Mesozoic deposits, and for it Lundgren was mainly responsible. He published two papers on the Palæontology of Spitzbergen, one in 1883, the other in 1887; the material for these was supplied by Nathorst and De Geer, who had collected it in the expedition of 1882. Lundgren's latest geological work was published in 1895, "On some Jurassic Fossils from Cape Stewart in Eastern Greenland." These were collected in the Danish Expedition of 1891–2.

In the spring of 1895 his health began to give way, although it is probable that he had for some time previously been threatened with the disease to which he finally succumbed. He died on the night of January 7 in the present year. G. L. E. (Translator).

(For these facts I am greatly indebted to the obituary notice written by Dr. Törnquist for the Geological Society of Sweden.—G. L. E.)